POTENTIAL EXPOSURE OF DIFLUBENZURON (DIMILIN®) TO BIRDS, NON-TARGET AQUATIC ORGANISMS, AND HUMANS

(A Cooperative USDA/STATE/USEPA Assessment)

September 22, 1978

U.S. DEPARTMENT OF AGRICULTURE
LAND-GRANT UNIVERSITIES
U.S. ENVIRONMENTAL PROTECTION AGENCY

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SUMMARY

An assessment was made of the possible levels of exposure to diflubenzuron (Dimilin) that might be experienced by birds, non-target aquatic organisms, and humans as a result of the anticipated uses of this insecticide on cotton, soybeans, hardwood and coniferous forests, and in mosquito control. The evaluation was conducted by U.S. Department of Agriculture, Land-Grant University Scientists, and U.S. Environmental Protection Agency, and was drawn from data available in USEPA files and published information.

Avian Exposure. Direct application of diflubenzuron to crops, forests, and water will result in low-level exposure of certain avian species to diflubenzuron residues, primarily through the diet. However, comparison of the maximum anticipated exposure levels to the demonstrated lowest effect levels of diflubenzuron on birds indicates that in no case will anticipated uses of diflubenzuron result in any discernible effects on birds, either acute or chronic. This is due both to low application rates of diflubenzuron in all proposed uses and to its demonstrated low acute and chronic toxicity to birds. Diflubenzuron will not accumulate to any appreciable degree in waters capable of supporting fish, it is not highly bioaccumulated by fish, and thus its use should result in only very minimal exposure to fish-eating birds

Exposure to Non-Target Aquatic Organisms. A variety of non-target aquatic organisms may be exposed to residues of diflubenzuron as a result of its use on water, crops, and forests. Studies have shown that diflubenzuron is not highly toxic to fish and other aquatic vertebrates. Based on available data, it appears likely that direct application of diflubenzuron to water for mosquito control will cause

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should minimize run-off from these environments because diflubenzuron adsorbs strongly onto organic matter. The potential for significant diflubenzuron movement away from application sites through run-off is further reduced by the fact that the compound generally has a short persistence in soils (half-life <7 days).

There are no experimental data available on the long-distance transport of diflubenzuron or any other pesticide down river drainage basins after run-off events. However, research personnel at the USEPA Water Quality Laboratory, Athens, GA, have utlized a mathematical model in an attempt to obtain some estimation of the compound's potential for entrance into and movement down major drainage basins. Projections were made of diflubenzuron residue levels entering streams at the point of field discharge, and these were coupled with projections of dilution, transport, and degradation in the mainstream flow to give projections of diflubenzuron concentrations at the mouths of selected river systems in the southern United States. The drainage basins of the rivers considered comprise much of the cotton and soybean production areas that will be subject to diflubenzuron treatment.

It must be emphasized that no direct experimental data regarding the run-off of diflubenzuron from treated fields was available for the development of the USEPA model. Further, many assumptions had to be made in the development of the model that allowed data output to be kept at manageable levels, yet some of these are not representative of either the likely diflubenzuron use patterns or of the environmental parameters likely to occcur. Assumptions in the model that are of particular significance include:

1) That weather patterns over all of the drainage basins are identical with respect to time and intensity and thus that run-off will take place in all fields in all basins at the same time. In reality, except for rare major storms

of hurricane proportions, summer rainfall in the cotton and soybean belts is almost always associated with localized thunderstorms, thus areas subjected to run-off at any one time will be a small fraction of the whole.

2) That crops will be treated with diflubenzuron at uniform rates on a beltwide, uniform schedule. Actually, the distribution in time of diflubenzuron applications throughout the cropping areas will be a continuum over the entire application season, with the frequency of application varying considerably, thus the likelihood of large scale run-off of freshly applied material from the cropped areas is greatly reduced.

3) That all of the cotton and/or soybean acreage within the drainage basins will be treated with diflubenzuron. This is not likely to occur, because projected use patterns of diflubenzuron indicate that on cotton and soybeans, actual acreages treated with diflubenzuron will probably not exceed about 15% and 5%, respectively, of the acreages planted to these crops.

4) That all run-off from treated areas will be discharged directly to flowing streams for immediate and continuous transport by rivers. However, major reductions in diflubenzuron concentrations through adsorption to soils, settling, and chemical breakdown, would take place as delays in movement over swales, ditches, or drainage systems occur.

Without compensation for the errors introduced by the assumptions listed above, the model projects that diflubenzuron residues discharged at the mouths of certain rivers would periodically reach the low part per billion range, although projected residues were generally sub part per billion. If the concentrations projected by the model did indeed occur periodically in water

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discharged by these river systems, adverse effects on populations of certain non-target aquatic organisms might occur. Based upon available laboratory toxicity data, the species potentially affected would include mysid-, grass-, and brine shrimp, and blue- and marsh crab.

Modeling projections of the levels of diflubenzuron or any other pesticide that might be discharged by major river systems would appear to be, at best, of limited value if the projections are not based on validated scientific parameters. In the case of diflubenzuron, there are no data indicating that the proposed uses of diflubenzuron will result in any residues being discharged into estuarine or salt water environments, thus the possibility that diflubenzuron may interact with any organisms in such environments still needs resolution.

Human Exposure: Dietary. Estimates were made of maximum or "worst case" dietary human exposure to diflubenzuron if the compound is used as an insecticide on cotton, soybeans, forests, and for mosquito control. The mosquito and forest applications of diflubenzuron will not likely lead to any significant residues entering the human food chain. Cotton and soybean uses may, however, result in exposure to diflubenzuron and/or its metabolites through direct human consumption of cotton or soybean seed and their processed fractions, and consumption of meat, milk, and eggs from livestock and poultry fed cottonseed and/or soybean seed fractions from diflubenzuron-treated crops. Fish may also be a source of dietary exposure to diflubenzuron, if run-off or drift from treated crops occasionally results in appreciable water residues that persist for several days.

"Worst Case" projections for all potential dietary sources of diflubenzuron indicate that even under the most adverse circumstances, diflubenzuron residues entering the human food chain will be extremely low. Based on available food

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consumption tables and the "worst case" levels of diflubenzuron that might appear in various foodstuffs, total diflubenzuron exposure to the average human will not exceed 0.00002840 mg diflubenzuron/kg body weight/day. Maximum dietary exposure to diflubenzuron residues of infants consuming formula containing soybean fractions would be on the order of 0.00024 mg/kg/day assuming that all of the soybean fractions in the formula contained 0.05 ppm diflubenzuron, the minimum sensitivity level of the analytical enforcement level. Taking into account that diflubenzuron will be used only on a relatively small proportion of the total cotton and soybean acreages (~15% and ~5% for cotton and soybeans, respectively) and that residues in seed of treated crops will in essentially all cases be below 0.05 ppm, it seems likely that average human dietary exposure to diflubenzuron will be much less, perhaps 1/10-1/100, of the "worst case" estimates obtained.

Human Exposure: Applicators, Field Workers, Bystanders. Projections were made of the potential exposure of diflubenzuron to applicators, field workers, and bystanders as a result of its use on cotton, soybeans, forests, and as a mosquito larvicide. These estimates suggest that persons involved directly in the application process (mixer/loaders, ground spray equipment operators, etc.) will be subject to considerably higher levels of diflubenzuron exposure than will either field workers or bystanders and residents present in or near the treated areas. Most of the potential exposure to applicators and associated personnel will be dermal rather than respiratory, and persons involved in the formulating (in the case of granular for mosquito control), mixing, and loading operations may be subject to potential diflubenzuron exposure at levels comparable to or higher than those of the applicators themselves. The number of bystanders potentially exposed to diflubenzuron will be greater as a result of its use on cotton and soybeans than for other applications, primarily because of

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the much larger acreages involved, higher number of repeat applications, and the number of residents within closer proximity to the treated fields. Current cultural practices for potentially treated sites are such that field workers (equipment operators, scouts, etc.) are not expected to receive substantial dermal or respiratory exposure as a result of the diflubenzuron applications. The estimates of potential human exposure to diflubenzuron generated here should be useful in any subsequent analysis of the possible risks associated with this insecticide.

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This assessment of the potential exposure of diflubenzuron to birds, non-target aquatic organisms, and humans was conducted by USDA, Land-Grant University scientists, and EPA. The responsibility for the contents rests with those individuals. However, scientists of the Water Quality Laboratory, Athens, GA, provided invaluable input into a portion of this assessment through discussions of their model of diflubenzuron movement through major river systems of the southern United States. These scientists included J. W. Falco, K. F. Hedden, and L. A. Mulkey. Useful discussions and analysis of the water transport model were also provided by R. A. Leonard, Southern Piedmont Conservation Research Laboratory, SEA, USDA, Watkinsville, GA.

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INTRODUCTION

In January 1978 the U.S. Department of Agriculture and the U.S. Environmental Protection Agency established a joint team to conduct a benefits/exposure assessment of the chitin synthesis inhibitor insecticide, diflubenzuron (Dimilin®). The document herein was generated by USDA, Land-Grant University Scientists and EPA to evaluate, to the extent possible, the degree of exposure to diflubenzuron that might be experienced by birds, non-target aquatic organisms, and humans (both through the human diet and by direct exposure to applicators, field workers, and bystanders) as a result of diflubenzuron use. This report arose primarily as the result of three meetings, at Crystal City, VA, April 25-26, 1978; Athens, GA, June 6-7, 1978; and Beltsville, MD, July 25, 1978. It is being provided to EPA and to the Joint USDA-STATE-EPA Benefits/Exposure Study Team on Diflubenzuron with the hope that it will be of value in the regulatory decision-making process concerning diflubenzuron.

PROJECTED EXTENT OF USE

The potential exposure associated with diflubenzuron will be directly related to the extent of use, and since diflubenzuron is currently registered only for control of the gypsy moth on hardwood forests, actual use experience is limited. Therefore, projections of potential use related to pending and projected registrations were made. Resource persons were assembled to develop estimates on possible diflubenzuron use in view of their knowledge of insect problems, of current control practices, and of research results with diflubenzuron. Estimates were made of quantities of diflubenzuron that might be used for control of (1) the boll weevil on cotton, (2) the velvetbean caterpillar, green cloverworm, and Mexican bean beetle on soybeans, (3) the gypsy moth on hardwood trees, (4) the Douglas fir tussock moth in western coniferous forests, and (5) mosquitoes breeding in intermittent fresh water.

The estimates generated (Table 1) are optimistic projections of uses that might be anticipated. These estimates are essentially the same as those that are being used in the benefits studies being conducted by the Joint USDA/State/EPA Study Team and are compatible with the pending labels for use on cotton and the originally proposed label for soybeans (Table 2). The estimates for gypsy moth will not be valid unless the current gypsy moth label or the current interpretation of the label by the USEPA is modified. However, the estimates were made in relation to the desired use envisioned by the USDA and its cooperators. Similarly, there is not a pending label for use of diflubenzuron against the Douglas fir tussock moth, but estimates are included because of the potential importance of this use. Also, estimates for the

[illegible] the extent of [illegible] and since diflubenzuron is currently [illegible] control of the gypsy moth on hardwood forests, actual [illegible] Therefore, projections of potential use related [illegible] distributions were made. Resource [illegible] possible diflubenzuron use in view of the [illegible] current control practices, and of research [illegible] [illegible] control of (1) the boll weevil on cotton, (2) the [illegible] green cloverworm, and [illegible] hardwood trees, (4) the Douglas-fir tussock moth [illegible] and (5) mosquitoes breeding in intermittent [illegible]

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Table 1. Projected extent of use for selected uses of diflubenzuron.

Pest	Site	Most likely rate (lb AI/Acre)	No. of appl.	Acres to be treated (in 1000's)	Treatment acres (in 1000's)	Lb AI
Boll weevil	Cotton	0.0625	6.0	1,540[a]	9,240	577,500
Velvetbean caterpiller	Soybeans	0.0312	1.	11,250[b]	1,375	42,900
Green clover-worm						
Mexican bean beetle						
Gypsy moth	Hardwood trees	0.0312	1.3	500[c]	650	20,300
Douglas-fir tussock moth	Conifer trees	0.125	1.0	44[d]	44	5,500
Mosquitoes	Inter-mittent water	0.025	1.0	400[e]	400	10,000
					11,755	656,200

[a] Based on acres in which insect control costs exceed $45/acre. Also, equal to about 50% displacement of current boll weevil insecticide on acreage requiring treatment. [b] Based on 50% replacement of insecticides now used for these insects. Acreage used in benefits analysis may vary slightly from this number. [c] Estimates of needs for control, containment, and eradication in government programs. These estimates are based on needs for 1979, 1980, and 1981. [d] Outbreaks occur about once every 9 years, if 400,000 acres were treated as a result of each outbreak, the annual average would be about 44,000 acres. [e] Expert estimate based on the potential replacement of up to 400,000 acres of 1,412,000 acres of intermittent water treated for larval control.

Table 2. Summary of proposed uses and maximum application rates for diflubenzuron.

Use	Rate Lb/AI/acre/application	Rate Maximum total lbs AI/season
Cotton	0.0625 - 0.125	0.75
Soybeans	0.0312 - 0.0625	0.125
Hardwood Forests (gypsy moth)	0.0312 - 0.0625	0.0625
Coniferous Forests (tussock moth)	0.125	0.125
Mosquito control	0.025 - 0.04	0.08

mosquito use are not compatible with the pending label, but were developed around the most critical needs for mosquito control with the assumption that label modifications might be made in the future to permit diflubenzuron use against mosquitoes on such important sites as flooded or irrigated pastures.

AVIAN EXPOSURE

USE PATTERNS AND APPLICATION RATES

This avian exposure assessment, for the uses of diflubenzuron on cotton, soybeans, intermittent fresh water, and forests, was based upon current or proposed labels as summarized in Table-2. Proposed application rates to cotton are 0.0625-0.125 lb AI/acre, with a maximum of 0.75 lb AI per acre per growing season. Proposed application rates to soybeans are 0.0312-0.0625 lb AI/acre, with a maximum of two applications per growing season. For control of the gypsy moth in hardwood forests, application rates are from 0.0312-0.0625 lb AI/acre with a maximum of one application per season. In coniferous forests for control of the Douglas-fir tussock moth, the application rate will be 0.125 lb AI/acre with a maximum of one application per season. The proposed application rate to intermittent fresh water for mosquito larvae control is 0.025-0.04 lb AI/acre with a maximum of two applications per year. The projected extent of use of diflubenzuron for each of these proposed applications (Table 1) has been discussed in the previous section.

ESTIMATED AVIAN EXPOSURE LEVELS

Dietary Weed Seed and Grit Exposure. Application rates at 0.0625 and 0.125 lb AI/acre, for soybeans and cotton, respectively, would result in maximum expected residues immediately following application, of 7.2 and 14.4 ppm to exposed seeds. Exposed grit, on these same treated areas, would have a comparable surface/volume ratio and, as such, would be expected to have similar residue levels as seeds. A wide variety of granivorous bird species inhabiting forest and agricultural ecosystems would be exposed to these residue levels.

Food Utilization: Soybeans. A number of waterfowl, song bird, and upland game bird species are known to utilize soybeans in their diets (Gusey and Maturgol, 1973). At the time of treatment, the soybean seed is within the unopened pod thus unexposed to the field application. The whole pod is expected to have a maximum residue level of 0.75 ppm assuming a maximum treatment rate of 0.0625 lb AI/acre. It is expected therefore that the seed itself will have even lower residue levels.

Douglas-Fir. It is anticipated that diflubenzuron will be applied at 0.125 lb AI/acre to suppress Douglas-fir tussock moth populations. As a consequence of that application maximum residues of 2.2 ppm were found to occur on Douglas-fir buds or newly emerging shoots (Shea, 1977). These buds or newly emerging shoots can be an important spring food source for forest dwelling grouse.

Fish. The highest rates in water would be most likely found immediately following direct application to water. The minimum water depth expected to contain a viable fish population is assumed to be about 6 inches. The maximum direct water treatment rate called for by the label is 0.04 lb AI/acre, which would produce a maximum expected residue in the water immediately following application of 14.7 ppb. The maximum reported uptake ratio from water to fish meat (Booth et al., 1976) is 134x found for bluegills. This factor, multiplied by the maximum water residue, is 1.97 ppm. Thus, the maximum potential dietary exposure of piscivorous birds feeding exclusively upon such fish would be on the order of 2 ppm.

METHODOLOGY

The calculated maximum expected residues in water or on vegetation were

derived mathematically from information contained in a USEPA criteria paper (Tucker, 1975). In turn, the basic data for this paper were largely adapted from Kenaga (1973). These papers, using surface-volume (weight) ratios, give calculations of deposited residues upon media of varying sizes and shapes assuming perfectly even spray deposition. They do not account for residue losses such as would be caused by drift, chemical breakdown, or other factors. Experimental data are given to show that these maximum expected residues can be obtained under ideal deposition conditions. These residue levels could only be exceeded by improper application techniques. The value given in these papers is 58 ppm/pound/acre for grain-sized seeds such as wheat. The value given for legume pods is 12 ppm/pound/acre. The base value given for water residue is 367.5 ppb/pound/acre on water exactly one foot deep. This value would occur if both perfect spray deposition and perfect mixing in the water occurred. This value does not take into account losses due to drift, adsorption, or chemical breakdown.

COMPARISON OF MAXIMUM EXPOSURE LEVELS TO LOWEST EFFECT LEVELS

Since the maximum calculable exposure levels appear to be well below the minimum effect levels shown for avian test species in all available valid long-term tests, no attempt will be made to quantitatively account for environmental factors that would tend to reduce both initial residue deposits and further diminish residues over time.

The theoretical maximum avian exposure for a single application from this analysis is 14.4 ppm by way of the diet. This figure is well below the lowest chronic effect level (40 ppm or greater) found in any valid avian toxicology study reviewed. Therefore, it seems reasonable to conclude that under the use patterns being proposed, diflubenzuron poses little acute or chronic danger to domestic or wild avian species.

MULTIPLE APPLICATIONS

There is no well-accepted mathematical model available for estimation of residues resulting from multiple applications of a pesticide to plant matter that may serve as feed for birds. However, the following method is proposed, in the absence of chemical-measured residues under field conditions. Initial residues are estimated by the methodolegy given in a USEPA Criteria paper (Tucker, 1975).

For a treatment rate of 0.125 lb AI/acre, the maximum expected initial surface residues for various dietary components of herbivorous birds are:

	PPM
seeds	7 (1*)
forage	7
leaves & leafy crops	16
long grass	14
short grass	30
debris (grit, dirt, etc.)	1
animal matter	1

At the time of the development of the USEPA Critera paper (Tucker, 1975), the label for cotton use allowed up to 12 applications at 0.125 lb AI/acre/ application at 5-day intervals. Thus, the calculations reported below are based on this prior label that allowed twice as much total diflubenzuron/acre on cotton as does the current label.

*1 ppm is used for this calculation on the assumption that about 85% of the residue on seeds would not be eaten if the bird rejected the seed hull when feeding.

APPLICATIONS

[illegible] is no well-accepted mathematical model available for estimation of [illegible] resulting from multiple applications of a pesticide to plant [illegible] serve as feed for [illegible]. However, the following method is proposed [illegible] based on chemical measured residues under field conditions. Initial [illegible] estimated by the methodology given in a USEPA Criteria paper (1975).

[illegible] treatment rate of 0.125 lb AI/acre, the maximum expected [illegible] is for various dietary components of herbivorous [illegible]

PPM
(15)

crops [illegible]
[illegible] 14
[illegible] 32
[illegible] 1
[illegible] etc. 1

[illegible] the development of the USEPA Criteria paper (Tucker, 1975), [illegible] allowed up to 12 applications at 0.125 lb AI/acre [illegible] intervals. Thus, the calculations reported below are based [illegible] that allowed twice as much total diflubenzuron [illegible] on [illegible] ment label.

[illegible] this calculation on the assumption that about 50% of [illegible] would not be eaten if the bird [illegible] the same [illegible]

Although vegetational half-life data are not available, both laboratory and field studies suggest that diflubenzuron will persist and accumulate on foliar surfaces (Verloop and Ferrel, 1977; Nimmo and deWilde, 1974). Although these data indicate that the half-life of diflubenzuron is greater than 2 months, it was assumed that plant growth would cause at least a two fold dilution of even the most persistent residues. Thus, a residue half-life of 60 days is a worst case situation.

A bobwhite quail's diet consists of approximately 87.5 percent vegetative matter, 10 percent animal matter and 2.5 percent debris (Stoddard, 1936; Tripanzee, 1948; Rosene, 1969). Of the vegetative matter eaten, nearly 76 percent and 4 percent consists of seeds and forage, respectively (Rosene, 1969). The additional 7.5 percent is comprised of long grass, short grass, leaves and leafy crops. Obviously, the exact breakdown of these secondary food sources varies considerably. As such, in order to simplify the calculations it was assumed that each of these food sources are consumed in equal amounts. Using these assumptions the following dietary profile for bobwhite quail was used to calculate exposure levels:

Seeds = 76 percent
Forage = 4 percent
Leaves and leafy crops = 2.5 percent
Long grass = 2.5 percent
Short grass - 2.5 percent
Debris = 2.5 percent
Animal matter = 10.0 percent

The formula used for residue contribution (in ppm) for any time of concern for each feed item resulting from each treatment is:

$$R.C. = R_0 (0.5)^{\frac{a}{h}}$$

[illegible] ional half-life data are not available, but laboratory and [illegible]udies suggest that diflubenzuron will persist and accumulate on fol[illegible]es (Verloop and Ferrel, 1977; Kramo and deWilde, 1974). Although the[illegible] indicate that the half-life of diflubenzuron is greater than [illegible] months, [illegible]sumed that plant growth would cause at least [illegible] persistent residues. Thus, a residue half-life of [illegible] days is a [illegible] [illegible]ation.

[illegible]bobwhite quail's diet consists of approximately [illegible] percent vegetative [illegible], 10 percent animal matter and 2.5 percent debris (Stoddard, 1936; [illegible]zee, 1948, Rosene, 1969). Of the vegetative matter [illegible] and 4 percent consists of seeds and forage, respectively [illegible] additional 7.5 percent is composed of long [illegible] and leafy crops. Obviously, the exact breakdown of these components [illegible]ries considerably. As such, in order to simplify the calculations, [illegible]sumed that each of these food sources are consumed in equal amounts. [illegible]ese assumptions the following dietary profile for bobwhite quail [illegible] calculate exposure levels:

[illegible]eaves and leafy crops = 2.5 percent
Long grass = 2.[illegible] percent
Short [illegible] = [illegible].5 percent
Debris = 2.5 percent
Animal matter = 10.0 percent

where, R.C. = residue contribution
R_o = initial time 0 residue deposit
h = residue half-life
a = age of residue (days) at time of concern

Table 3 gives the computed residue contribution by feed type for each dietary component on day 55, the day of the last diflubenzuron application. Once the residue profile has been constructed, the next step is to determine what proportion of a bird's daily diet is made up of each vegetational type. By multiplying the proportion of the bird's diet by the residue expected to occur on the vegetational type (see Table 3), the dietary intake of toxicant associated with each vegetational type can be determined. By summing the intakes associated with each vegetational type, estimates of the total daily dietary intake can be made.

1. Seeds = .76 (8.91) = 6.77
2. Forage = .04 (62.37) = 2.49
3. Leaves and Leafy crops = .025 (142.56) = 3.56
4. Long grass = .025 (124.74) = 3.11
5. Short grass = .025 (267.30) = 6.68
6. Debris = .025 (8.91) = 0.22
7. Animal matter = .10 (8.91) = 0.89

Total PPM in diet (sum of above): 23.72

As in the previously described scenario following a maximum single application, residue levels from multiple applications appear to be below the minimum effect level such that no chronic reproductive effects are expected. The fact that current label restrictions reduce the maximum amount of diflubenzuron applied to cotton by 50% over that assumed in the above calculations is an even more definitive indication that such use will have no discernible effects on avian species.

Table 3. Projected Diflubenzuron Residues by Vegetational Type after 12 Applications of Diflubenzuron (0.125 lb AI/acre/application) at 5-day Intervals.

No. of Applications (5-day intervals)	$\frac{a}{h}$	SEED	FORAGE	LEAVES AND LEAFY CROPS	LONG GRASS	SHORT GRASS
1	55/60	0.53	3.71	8.48	7.42	15.90
2	50/60	0.56	3.92	8.96	7.84	16.80
3	45/60	0.60	4.20	9.60	8.40	18.00
4	40/60	0.63	4.41	10.08	8.82	18.90
5	35/60	0.67	4.69	10.72	9.38	20.10
6	30/60	0.71	4.97	11.36	9.94	21.30
7	25/60	0.75	5.25	12.00	10.50	22.50
8	20/60	0.79	5.53	12.64	11.06	23.70
9	15/60	0.84	5.88	13.44	11.76	25.20
10	10/60	0.89	6.23	14.24	12.46	26.70
11	5/60	0.94	6.58	15.04	13.16	28.20
12 IR*		7.91	55.37	126.56	110.74	237.30
Total Res. Cont.		8.91**	62.37	142.56	124.74	267.30

*IR = Initial Residue
**Use this value for Debris and Animal matter residues

EXPOSURE TO NON-TARGET AQUATIC ORGANISMS

DIRECT APPLICATION TO AQUATIC HABITATS FOR MOSQUITO CONTROL

The W25 (25% Wettable powder) formulation and W-25 granule (formulated by abatement district personnel using 30 pounds of W-25 formulation, 2957 pounds of 20/30 mesh coarse sand, 10 pounds of larvicide oil and 3 pounds of Hysil) will probably be used to control mosquito larvae in overflow, intermittently flooded sites associated with urban and residential areas, drainage ditches and lagoons from dairy and swine holding areas, and temporary rain and snow pools. For control of mosquito larvae including Culex, Anopheles, Psorophora, and Aedes species diflubenzuron will probably be used at the rate of 0.025-0.04 lb AI/acre of water. For aerial application, diflubenzuron will probably be applied in 0.5 to 4 gallons of water/acre and for ground application in 5-100 gallons/acre according to the type of equipment used. Repeat applications can probably be made in 7 to 9 days or as inspection indicates increase in density of 4th instar larvae or reappearance of first instar larvae in the breeding habitat. The granular formulation should be used promptly at the rate of 10 to 16 pounds per acre.

The acute effects of direct applications of diflubenzuron to aquatic habitats at application rates of 0.04 lb AI/acre (0.03 ppm in water 15 cm deep) on non-target aquatic organisms have been summarized (Table 4). Tadpole shrimp, clam shrimp, Daphnia, Mysid shrimp (Mysidopsis bahia), Gammarus, glass shrimp, Notonecta unifasciata, Brine shrimp, Midges, and May fly (Callibaetis) populations would be reduced some 50% or greater by diflubenzuron applications applied at rates used to control mosquito larvae. Field test data show that all organisms listed in Table 5 would be reduced by at least 33% as a result of one diflubenzuron application at the registration request rates of application

Table 4. Laboratory tests - Acute toxicity of diflubenzuron to certain non-target aquatic organisms.

	LC_{50} ppm				
Reference Cited	Very Sensitive	Reference Cited	Sensitive	Reference Cited	Tolerant
1	Tadpole shrimp 0.0006 (24 hr)	6	Notonectid 0.01 (72 hr LC_{30})	1	Seed shrimp 5.0 (24 hr)
1	Clam shrimp 0.0004 (24 hr)	5	Callibaetis 0.3 (7 day)	1	Copepods 10.0 (24 hr)
1	Daphnia 0.018 (48 hr)	5	Dragonfly 0.05 (7 day)		
2	Gammarus 0.04 (48 hr)	5	Hydrophilid 0.1 (48 hr LC_{30})		
3	Glass shrimp 0.045 (48 hr)	4	Midge larvae 0.56 (48 hr)		
		4	Grass shrimp 0.64 (48 hr)		

1. Miura and Takahashi (1974). 2. Julin and Sanders (1978). 3. Campt (1977). 4. Petrocelli, (1975). 5. Miura and Takahashi (1975). 6. Miura et al. (1975).

Table 5. Effects of diflubenzuron on non-target aquatic organisms - Field Data.

Reference Cited	Organism	Concentration (PPM)	% Reduction
2	Daphnia (recovered in 8 weeks)	0.003	+99
1	Copepods	0.013	50
1	Daphnia (recovered in 6 weeks)	0.013	+99
3	Daphnia (recovered in 2 weeks)	0.03	+90
4,6	Dragonfly	0.03	33 - 50
4	Notonectids	0.03	67
3	*Laccophilus*	0.03	30
4,5,6	Hydrophilids	0.03	50
2,7	Copepods	0.03	47 - 60
4	Corixidae nymphs	0.03	40
4	*Hyallella azteca*	0.03	57
7,5	Mayflies	0.03	50 - 64
9	*Palaemonetes pugio*	0.03	85
9	*Uca pugnax*	0.03	43
8	*Cyclops* sp.	0.012	100
8	*Boxmina longirostris*	0.012	100
8	*Diaptomus* sp.	0.012	100
8	*Daphnia laevis*	0.012	100
8	*Ceriodaphnia*	0.012	100
8	*Caenis* sp	0.012	99
8	*Hyalella azteca*	0.012	100

1. Colwell and Schaefer (1978). 2. Apperson et al. (1978). 3. Miura and Takahashi (1975). 4. Farlow et al. (1978). 5. Miura et al. (1975). 6. Steelman et al. (1975). 7. Mulla et al. (1975). 8. Ali and Mulla (1978). 9. McAlonan (1976).

(0.025-0.04 lb AI/acre). Field test data indicated that no organism populations shown in Table 6 were reduced by as many as 6 applications of diflubenzuron at the 0.025 lb AI/acre rate of application over an 18 month period.

DIRECT APPLICATION TO AQUATIC HABITATS BY AIRCRAFT APPLYING DIFLUBENZURON TO COTTON, SOYBEANS, AND FORESTS.

Farm ponds, lakes, rivers, or any other aquatic habitat can receive relatively heavy doses of pesticides due to inadvertent direct spray from aerial applications (Stewart et al., 1976). A worst case would be the application of diflubenzuron to an aquatic habitat at the highest rate likely in the registration for use of diflubenzuron on cotton, or for tussock moth control in forests (0.125 lb AI/acre). In this case, the aerial applicator would fail to 5 stop the application at the end of the area to be treated and continue to apply diflubenzuron at a rate of 0.125 lb AI/acre over an aquatic habitat (i.e., farm pond, drainage canal, lake, stream, etc.). This would result in a relatively high concentration of diflubenzuron being applied directly to the aquatic habitat. If the aquatic habitat was 15 cm deep, this would result in an initial concentration of 100 ppb in the total volume of water covered by the application. Fifteen centimeters of water was chosen for this example of worst case since it represents an aquatic habitat that would support some species of fish as well as other aquatic taxa. At this concentration of diflubenzuron in the aquatic habitat, certain organism populations listed in Table 4 would be effected at the LC_{50} response level or probably above this level in some cases (tadpole shrimp, clam shrimp, Daphnia, Mysid shrimp, Gammarus, glass shrimp, notonectids, and dragonflies listed in Table 4 and all taxa listed in Table 5).

Table 6. Effects of diflubenzuron on non-target aquatic organisms - Field Studies - No Population Reduction at 0.03 ppm.

Reference Cited	Organism	Reference Cited	Organism
4,6	Midge larvae	5	copepod
4	*Callibaetis*	4	notonectids
4	*Physa* sp.	4	*Hydrovatus cuspidatus*
4	*Mesovelia mulsanti*	4	*Trichocorixa louisianae*
4	*Caenis* sp.	4	*Callibaetis* sp.
4	Noteridae	4	*Hydrovatus* sp.
4	*Bidessini*	4	Chironomidae
4	Ephydridae	4	Dolchopodidae
4	Tabanidae	4	*Gambusia affinis*
4	*Jordanella floridae*	4	*Buenoa* sp.
4	*Berosus exiguus*	4	*Tropisternus laterilis*
4	*Enochrus blatchleyi*	4	*Laccophilus proximus*
4	*Hydrocanthus sp.*	4	*Suphisellus sp.*
4	*Celina angustata*	4	*Onychylis nigriostris*
4	*Listronotus appendiculatus*	4	*Lissorhoptrus* sp.
4	*Belostoma* sp.	4	*Taphromysis louisianae*
4	*Paleamonetes paludosus*	4	*Procambarus clarki*
4	*Berosus* sp.	4	*Tropisternus* sp.
4	*Enochrus* sp.	4	*Laccophilus*
4	Muscidae	4	Stratiomyiidae
4	*Pachydiplax* sp.	4	*Belonia* sp.
4	*Anax* sp.	4	*Mesovelia* sp.
4	*Liodessus affinis*	4	*Cambarellus* sp.

4 - Farlow et al. (1978). 5 - Mjura et al. (1975). 6 - Steelman et al. (1975).

This treatment of the aquatic habitat represents the immediate residue level to which these non-target organisms would be exposed and does not include reduction in residue concentrations caused by dilution by untreated or running water, uptake on sediment, or breakdown of the parent compound in the treated habitat. This situation does occur in some areas likely to be treated with diflubenzuron, thus, the initial situation was presented as a worst case.

CONTAMINATION OF ADJACENT GROUND AND WATER BY DRIFT OF DIFLUBENZURON FROM AERIAL APPLICATIONS TO COTTON AND SOYBEAN FIELDS, AND FORESTS.

Farm ponds or any aquatic habitat can receive relatively heavy doses of pesticides by drift from aerial applications (Stewart et al., 1976). Based on drift deposition data derived from Yates et al. (1974), we calculate that the decrease in deposition rate with outward distance from the edge of a large crop area treated at 0.125 lb AI/acre (150 g/ha) will decrease as follows (area treated by 60 swaths):

Distance [a] (meters)	Deposition Rate lb AI/acre	g/ha	Concentration in Water[b] 15 cm depth in ppb
0	0.125	150	100
25	0.125	150	100
45	0.076	92	62
100	0.040	49	33
200	0.024	29	19
400	0.014	16	11
800	0.0082	10	6.7
1200	0.006	6.7	4.5

[a] These calculations are for the drift dispersion of a formulation of diflubenzuron in cottonseed oil, which travels about 1.5 x further than a water-based emulsion. Flight conditions as described in Table 7.

[b] No allowance was made for attachment of diflubenzuron to sediments.

[illegible] sent of the aquatic habitat represents [illegible]
[illegible] hich these non-target organisms would be exposed and does not [illegible]
[illegible] in residue concentrations caused by dilution by [illegible]
[illegible] ptake on sediment, or breakdown of the parent compound [illegible]
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[illegible]ATION OF ADJACENT GROUND AND WATER [illegible]
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[illegible] ponds or any aquatic habitat can receive relatively [illegible]
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[illegible] ied at 0.125 lb AI/acre (150 g/ha) will decrease [illegible]
[illegible] by [illegible] swa ns).

Deposition Rate lb AI acre	g/ha	Concentration [illegible]	[illegible]
0.125	150		[illegible]
0.125	150		[illegible]
0.076	92		[illegible]
0.040	49		[illegible]
[illegible]	[illegible]		[illegible]
[illegible]	[illegible]		[illegible]
[illegible]	[illegible]		[illegible]
[illegible]	[illegible]		[illegible]
0.00[illegible]	[illegible]		

[illegible] for the drift [illegible] of [illegible]
[illegible] which travels about 1.5 [illegible]
[illegible] conditions as described in Table [illegible].

[illegible] achment of [illegible]

Table 7. Cumulative off-target drift deposits from 20, 40, and 60 adjacent 33 feet wide swaths applied with a stearman aircraft[a, b] (upper 99% confidence limit).

Distance Downwind, Ft.	% of Applied Volume[c, d]		
	(20 Swaths-1/8 mi)	(40 Swaths-1/4 mi)	(60 Swaths-3/8 mi)
83	64.9	70.9	74.9
149	31.5	37.4	40.9
314	14.0	18.5	21.8
644	6.6	9.6	12.6
1304	3.2	5.7	7.4
2624	1.7	3.2	4.4
3944	1.2	2.2	3.0

[a]Parameters: Nozzles - Spraying Systems D6-45; Nozzle Orientation - Down; Application Rate - 3.7 GPA (Mean of 3 Tests); Spray Material - Oil/water Emulsion; Wind Speed (Crosswind) - 8.2 MPH (mean of 3 Tests); Stability Ratio - 0.20-0.74 (Stable); Nozzle Pressure - 38-41 PSI; Airspeed - 100 MPH; Drop Size - 175μ VMD; Height of Flight: 2-5 feet. [b]Computed from data in Table 3 of Yates et al. (1974). [c]Based on 99% confidence limits. Actual regression line would give values 2/3 of the 99% C.L. values. [d]When oil only is used with diflubenzuron, multiply values by 1.5.

... off-target drift deposits from 20, 40, and 80 ... waths applied with a Stearman aircraft. (under ... flight)

% of Applied Volume		
(20 Swaths-1/8 mi)	(40 Swaths-1/4 mi)	(80 Swaths-1/2 mi)
64.5	[illegible]	[illegible]
31.2	[illegible]	[illegible]

...ameters: Nozzles - Spraying System ...; Spray Rate ... Application rate - 3.7 GPA (Mean of 3 Tests); ... Wind Speed (Crosswind) - 8.2 MPH (Mean of 3 Tests); ... Nozzle Pressure - 38-41 PSI; Airspeed - 100 MPH; ... Height of Flight: 2-5 feet. Computed from data in Table 3 ... Based on 99% confidence limits. Actual regression line would ... of the 99% C.L. values. When ... only ... used with multiply values by 1.5.

The water concentrations are those which would be caused by deposition of drift on the surface area of an open pond or aquatic habitat at these distances from the edge of a sprayed area; the diflubenzuron being uniformly distributed through the 15 cm depth (6 inches, total volume).

There is no allowance for removal of diflubenzuron by adsorption on organic matter or sediment in or under this aquatic habitat. Such adsorption would reduce the concentration of diflubenzuron to much lower levels. These levels cannot be calculated without postulating given amounts of sediment, but reduction to values less than 10% of the calculated values will happen rapidly.

The drift of diflubenzuron over aquatic habitats previously discussed would result in concentrations of 6.0 ppb in water 6 inches in depth that would be acutely lethal (LC_{50}) to tadpole and clam shrimp, *Daphnia*, and mysid shrimp at a distance of 1200 meters from the edge of the treated field. At distances of 0 to 25 meters, the concentration would be 100 ppb in 6 inches of water, thus, acutely affecting tadpole and clam shrimp, *Daphnia*, mysid shrimp, *Gammarus*, glass shrimp, notonectids, dragonfly naiads, and Hydrophilid larvae (Table 4), as well as all taxa listed in Table 5.

Although information and data are not available to calculate estimates of deposits from drift of diflubenzuron during aerial application to forests, the data in Table 7, along with appropriate adjustments, can serve as a guide to expected deposit levels. Greater vegetation height and increased variability of terrain over that found in cotton and soybean applications result in greater heights of spray release and potentially increased drift. However, the screening effect of tall trees tends to reduce drift deposits at ground level (many drifting particles deposit on the foliage before they can reach the

he concentrations are those which would be found in deposition of [illegible] surface area of an open pond or equal a deposit at [illegible] distances ge of a sprayed area, the diflubenzuron being [illegible] only distributed e 15 cm depth (6 [illegible] total volume).

e is no allowance for removal of diflubenzuron by adsorption [illegible] diment [illegible] or under this aquatic habitat. Such [illegible] educe the concentration of diflubenzuron to much lower [illegible] evels cannot be calculated without postulating given [illegible] of sediment, ction to values less than 10% of the calculated [illegible] will happen

drift of diflubenzuron over aquatic habitats [illegible] (Greatest [illegible] concentrations of 6.0 ppb in water [illegible] inches in depth [illegible] ethal (LC_{50}) to [illegible] and clam shrimp, Daphnia, and [illegible] of 1000 meters from the edge of the treated [illegible] 5 meters, the concentration would be 1.0 ppm in 3 inches of water. affecting tadpole and clam shrimp, Daphnia, [illegible] shrimp, [illegible] shrimp, notonectids, dragonfly naiads and Hydrophilid (Table 4), as well as all taxa listed in Tab[illegible] ugh information and data are not available to calculate estimates [illegible] the drift of diflubenzuron during aerial application to forests. [illegible] le 7, along with appropriate adjustments, can serve as a guide to est levels. [illegible] height and increased variability of [illegible] found in cotton and soybean applications result in greater [illegible] increased drift. However, the [illegible] to reduce drift deposits at ground level [illegible] foliage before they can reach the

ground). When coupled with the low rate of application (0.0312-0.125 lb AI/acre) and the fact that only one application per season is expected for gypsy moth or tussock moth control, these factors suggest that drift deposits from forest treatments will likely be significantly lower than those for cotton or soybeans.

DIFLUBENZURON RUN-OFF FROM TREATED COTTON AND SOYBEAN FIELDS, AND FORESTS

The estimates of the concentrations of diflubenzuron that may be expected in aquatic systems affected by run-off from treated areas have been made in three ways.

1. By evaluation of laboratory or field residue studies dealing directly with the runoff potential of diflubenzuron.
2. By analogy and extrapolation from data with other pesticides. This, however, is limited to small watershed areas where actual observations exist.
3. Using projections based upon computer calculations with models that use inputs defining weather, streamflow, soil properties, descriptions of use patterns, and chemical properties of the pesticide. Procedurally, these calculations lead to predictions of water flow, sediment production and the amount of pesticide transported. Depending on the extent of the assumptions made, pesticide concentrations can be estimated both close to treated areas and at distances down stream channels.

Estimates of potential diflubenzuron runoff based on extrapolation from data on other pesticides or on computer calculations using models are based on the same projected usage. For cotton, this is four applications of 0.0937 lb AI/acre (43 g/hectare) at seven-day intervals beginning on June 15th each

year. The total application is thus 0.375 lb/acre (170 g/h). For soybeans two applications, each of 0.0312 lb AI/acre (14 g/h) are projected for a total of 0.0625 lb/acre (28 g/h). Maximum forest application would be one application/year at either 0.0625 (gypsy moth) or 0.125 (tussock moth) lb AI/acre. Each of these usages is consistent with the proposed label.

Laboratory and field run-off studies. Two studies are available that deal directly with the run-off potential of diflubenzuron. One of these (Gemma, 1975) was a laboratory investigation in which diflubenzuron (Dimilin W25, 1 lb AI/acre equivalent) was applied to the surface of a Missouri Valley clay loam soil in an inclined tray (10% slope). Artificial rainfall (~1.5 inches over a 2-hour period) was then provided at 1, 3, and 7 days after treatment, and the run-off water was collected and analyzed for diflubenzuron residues. The results of the analyses showed that in all cases, diflubenzuron residues in the run-off water were <0.01 ppm.

A recent study by Collins (1978), reported the levels of diflubenzuron in water (Chowan County, North Carolina) resulting from diflubenzuron's use in the pilot boll weevil eradication program. Water samples were collected from several streams and tributaries receiving run-off from diflubenzuron-treated cotton fields, and were analyzed for diflubenzuron residues. The fields had received as many as 16 treatments of diflubenzuron during 1976-77 (0.03-0.06 lb AI/acre/treatment), with application of the 25 WP formulation made by fixed-wing aircraft. Analysis of numerous water samples (collected during 1977) showed that residues were in all cases <0.005 ppm diflubenzuron, the sensitivity of the analysis procedure.

Comparison with other pesticides. The potential runoff of diflubenzuron was considered in light of available data on other pesticides. In the case of cotton, since diflubenzuron will be applied to a closed canopy of mature cotton

The [illegible]tal application is thus 0.375 lb/acre (420 g/h). For soybeans [illegible] applicat[illegible]ons each of 0.0312 lb AI/acre (34 g/h) are projected for a total [illegible] [illegible]25 lb/acre (28 g/h). Maximum forest application would be one [illegible] [illegible]t on/year at [illegible] 0.0625 (gypsy moth) or 0.125 (tussock moth)

[illegible] Each of these usages is consistent with the proposed [illegible].

[illegible] aborator[illegible] and field run-off studies. Two studies are available that deal [illegible]y with the run-off potential of diflubenzuron. One of these (Gomma, [illegible] was a laboratory investigation in which diflubenzuron (Dimilin W[illegible] [illegible] equivalent) was applied to the surface of a Missouri [illegible] [illegible] [illegible] inclined tray (10% slope). Artificial rainfall (1.5 inches ove[illegible] [illegible] period) was then provided at 1, 3 and [illegible] days after treatment, and the [illegible]ater was collected and analyzed for diflubenzuron residues. The [illegible] the analyses showed that in all ca[illegible] [illegible] [illegible]wa[illegible]er were <0.01 ppm.

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[illegible] [illegible]esticides. The potential runoff of diflubenzuron [illegible] [illegible] available [illegible] on other pesticides. In the case of [illegible]

plants, it is assumed that 30% reaches the soil directly. Bull and Ivie (1978) showed that 23% remained on the leaves 21 days after application, following a heavy rain. We therefore assume that 75% would wash off, so that for each application of 43 g/h, we should have

Initially on soil	12 g
Initially on plants	30 g
Wash-off (30 x 0.75)	23 g
Total on soil for run-off	36 g

Assuming the half-life of diflubenzuron on the soil to be 7 days, the amount present on the soil after the last application to cotton will be 67.5 g/hectare (36 + 18 + 9 + 4.5). Applications to soybeans will be less regular in time, but it may be assumed that there would be about 20 g/hectare after a second appliction. Choosing a worst possible case from Stewart et al. (1976), as shown in Table 8, we may envision losses up to 10-15% of that on the soil in heavy run-off from cotton or soybeans grown on steep land (15% slope). On more representative cropland areas (5% slope or less), the worst probable loss is not likely to exceed 1% of soil residues. On this basis, we calculate:

Table 8. Percentages of applied pesticides lost in runoff[a] in field experiments[b]

Pesticide	Incorporated Depth (inches)	Soil Texture	Slope %	Pesticide in runoff (% of appl.)	Citation
Atrazine	0	Silty clay loam	14	4.8-5.0	Hall (80)
Atrazine	0	Silty clay loam	14	2.6	Hall, Pawlus, and Higgins (81)
Atrazine	0	Silt loam	10-15	2.5-15.9	Ritter et al. (134)
Carbaryl	2	Silt loam	10	0.1	Caro, Freeman, and Turner (36)
Carbofuran	3	Silt loam	9	0.9	Caro et al. (35)
Carbofuran	2	Silt loam	10	1.9	Caro et al. (35)
DDT	0	Loamy sand	2-4	1.0-2.8	Bradley, Sheets, and Jackson (27)
DDT	0	Gravelly loam	8	0.7	Epstein and Grant (63)
Dieldrin	3	Silt loam	14	2.3	Caro et al. (34)
Dieldrin	3	Silt loam	10	0.02	Caro et al. (34)
Endosulfan	0	Gravelly loam	8	0.25-0.35	Epstein and Grant (63)
Endrin	0	Gravelly loam	8	0.01-1.0	Epstein and Grant (63)
Endrin	0	Silty clay loam	0.2	0.1	Willis and Hamilton (169)
Fluometuron	0	Various	0.1-4	<3.0	Wiese (167)
Methyl parathion	0	Loamy sand	4	0.01-0.02	Sheets, Bradley, and Jackson (142)
Methyl parathion	0	Sandy loam	2	0.13-0.25	Sheets, Bradley, and Jackson (142)
Propachlor	0	Silt loam	10-15	3.1	Ritter et al. (134)
Toxaphene	0	Loamy sand	2-4	0.4-0.6	Bradley, Sheets, and Jackson (142)
Trifluralin	6	Loamy sand	4	0.3-0.5	Sheets, Bradley, and Jackson (142)
Trifluralin	6	Sandy loam	2	0.5-0.8	Sheets, Bradley, and Jackson (142)

[a]Both water and sediment. [b]From Stewart et al. (1976). [c]See Stewart et al. (1976) for complete reference citations.

Crop	Soil Residues (g/h)	1% loss	10-15% loss
		g/hectare	
Cotton	67.5	0.7	7 - 11
Soybeans	20	0.2	2 - 3

If these totals are carried in 1" of run-off water (2.5 cm), the projected concentrations will be:

Crop	Overall concentrations (ppb)	
	1% loss	10-15% loss
Cotton	2.8	28 - 44
Soybeans	0.8	8 - 12

Transport of the same amounts in less water would give proportionally higher concentrations, and it is conceivable that if the assumptions forming the basis of these calculations are correct, concentrations could approach 100 ppb in run-off from very steep land.

Calculation of the distribution of this total diflubenzuron between water and sediment would require assumptions about sediment concentration in the

run-off and also its particle size distribution. Since these are uncertain numbers that change rapidly with time, projection of this distribution for the rapidly changing situation at the foot of the field is without significance. Adsorption of diflubenzuron by sediments is, however, of more significance in long-distance transport.

These calculations may be compared with earlier experience with residues of other pesticides that has shown that concentrations of pesticide residues in the waters of farm ponds located adjacent to treated cropland areas are correlated with the amount of pesticide applied in the area and the length of time between the application and the first heavy rain. Data have been published which indicate that pesticide concentrations in ponds located near cotton fields were significant after application and especially high when intense rain closely followed the application. Pesticide concentrations in these aquatic habitats were high (55-184 ppb) if the first rainfall occurred within 2 weeks after application. By contrast, if the first rainfall occurred 6 weeks after application, the pesticide residues were only 2-29 ppb. There are also reports that indicate that farm ponds are not always contaminated from rainfall run-off pesticide residues even when adjacent to treated croplands (Stewart et al., 1976).

If, following Nimmo and de Wilde (1975), we assume a decrease in diflubenzuron residues in cotton fields with a half life of 1 week, residues will be down to about 25% of the applied concentration by July or August. Bull and Ivie (1978) reported that there was little further decline in residues over the winter. If the soil remains undisturbed without plowing or cultivation, we may therefore assume that erosion in the late winter or early spring would release up to 20% of a similar event to that which had occurred 9-10 months earlier. The predicted values in this second event would then be 1/5 of those

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calculated for immediate rainfall run-off. However, if the soil is plowed or cultivated, the winter or spring losses will be much less. Assuming that the residues were present in the top 1 cm of soil before plowing and are uniformly distributed through the 15 cm depth afterward (= 15 x dilution), the fraction of the original application remaining on the surface and liable to loss in run-off in the late winter or spring would be no greater than 1.3% (= 20%/15) of that lost in a similar event 9-10 months earlier. The predicted concentrations for this second event would then be between 1 and 2 % of those calculated for immediate run-off. If the diflubenzuron were not uniformly mixed to the 15 cm depth, but wholly buried by the inversion of the topsoil during plowing, the concentrations would not exceed 0.1% of those in immediate run-off.

The use of diflubenzuron in forest insect control will often be associated with lands of considerably greater slope than in the case with cotton and soybean production, but there are no experimental data to indicate the extent of run-off from treated forests. However, application rates on forests are low with respect to the potential application rates on cotton, and it is known that diflubenzuron adsorbs strongly onto organic matter (Nye, 1977). Thus, the high organic content of the forest floor should minimize run-off from these environments.

PROJECTION OF RUN-OFF AND TRANSPORT USING MATHEMATICAL MODELS

Since there are essentially no observational data available on the long-distance transport of pesticide residues down stream channels after individual run-off events, no projections for diflubenzuron based on the behavior of other chemicals are possible. However, a mathematical approach for projecting diflubenzuron loadings and concentrations in several river systems has been taken using Version II of the USEPA Agricultural Run-off Management (ARM) Model

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developed by Donigan et al. (1977). This calculation gives projections of diflubenzuron concentrations entering streams at the point of field discharge into streams. This, coupled with calculations of dilution, transport, and degradation in the mainstream flow further permits calculation of projected concentrations and persistence of diflubenzuron at downstream points remote from the application areas. Complete details of the calculation and results are available (Falco et al., 1978). The immediate discussion that follows will be confined to a presentation of the principal results and a discussion of the significance of the results in terms of the assumptions made.

Areas Selected. Calculations were completed for the drainage basins of the Tombigbee, Brazos, Colorado, Atchafalaya, and Nueces rivers, all of which drain directly into the Gulf of Mexico, and for the lower Mississippi, comprising the St. Francis, Arkansas, White, Yazoo, and Big Black rivers. All were chosen because they contain large cotton and soybean acreages and have high potential for run-off. The results of similar calculations for the Rio Grande, Trinity, and Pearl rivers were not used in the final analyses for reasons discussed below.

Selected Cropping Patterns. The calculation was performed assuming that diflubenzuron would be applied to cotton alone, and repeated assuming that both cotton and soybeans would be treated. Total acreages for both crops in each basin were estimated from data supplied by State Reporting Services. It was further assumed that the entire crop in each watershed would be treated according to the schedule described above; no allowance was made for the possible effects of partial treatment of the land area, or variations in application schedules. This assumption was necessary to keep the amount of computation within the practical limits and to avoid excessive proliferation of output results.

Weather Conditions. The rainfall and evaporation patterns over all the river basins were assumed to be those reported for Beeville, Texas. This location was the only suitable reporting station for which sufficient data were readily available. Calculations were run with rainfall patterns for each year from 1971 to 1975. The error in the estimates arising from the assumption that it rained everywhere in all the basins at the same time and with the same intensity and duration is thus partially offset by the range of conditions experienced over these years. It may be noted that the occurrence of an unusually heavy storm in 1971 permits the inclusion of the calculated consequences of such an event.

Stream flow data. Daily observations of stream flow data from 1971 to 1975 used in the calculation of stream dilution and transport were obtained from United States Geological Survey files; no calculation was performed where data did not exist. Estimated times of travel for each river were obtained from the United States Army Corps of Engineers.

Soil Stability and Hydrologic Characteristics. The necessary parameters describing soil behavior and effects of crop management on run-off and erodibility were obtained from United States Soil Conservation Service data. Details of these model inputs, together with those for crop areas, stream flow, sediment loads, and travel times are available (Falco et al., 1978).

CALCULATED CONCENTRATIONS IN COASTAL DISCHARGES

The maximum projected daily concentrations in the water at the mouths of rivers, assuming the weather patterns of 1971 through 1975, are presented in Table 9. Table 10 contains the average daily concentrations for the summer of each year at the same locations. Both Tables contain separate estimates for loadings caused by applications to cotton alone and by applications to cotton

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Flow data. Daily observations of stream flow data from 1971 to 1975

calculation of stream dilution and transport were obtained from

the Geological Survey files; no calculation was performed where data

exist. Estimated times of travel for each river were obtained from the

States Army Corps of Engineers.

Soil and Hydrologic Characteristics. The necessary parameters

soil behavior and effects of crop management on runoff and

ity were obtained from United States Soil Conservation Service data.

of these model inputs, together with those for crop acres, stream flow,

and travel times are available (Felton et al., 1978).

CONCENTRATIONS ... COASTAL DISCHARGES

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Table 9. Maximum estimated daily diflubenzuron concentrations at river mouths for 1971 through 1975[a]

Basin	Year	Diflubenzuron Concentration (ppb)	
		Cotton	Cotton & Soybeans
Mississippi	1971	1.8	3.2
Atchafalaya	1971	2.1	3.6
Tombigbee	1972	0.2	0.8
Brazos	1974	3.7	3.7
Colorado	1971	14	27
Nueces	1975	38	38

[a]from Falco et al. (1978).

Table 10. Average estimated daily summer concentrations of diflubenzuron at river mouths for 1971 through 1975.[a]

Basin	Year	Diflubenzuron Concentration (ppb)	
		Cotton	Cotton & Soybeans
Mississippi	1971	0.20	0.34
	1972	0.09	0.15
	1973	0.11	0.19
	1974	0.06	0.11
	1975	0.05	0.08
Atchafalaya	1971	0.29	0.50
	1972	0.13	0.23
	1973	0.11	0.20
Tombigbee	1971	0.03	0.12
	1972	0.05	0.16
	1973	0.05	0.15
	1974	0.02	0.06
	1975	0.01	0.03
Brazos	1973	0.49	0.52
	1974	0.71	0.71
	1975	0.29	0.29
Colorado	1971	1.46	2.04
	1972	1.31	1.84
	1973	0.41	0.56
	1974	0.20	0.28
	1975	0.08	0.12
Nueces	1973	1.28	-
	1974	0.83	-
	1975	1.20	-

[a]from Falco et al. (1978).

and soybeans taken together.

Data for the Rio Grande are not included because the rainfall patterns at Beeville, Texas were probably not representative of this river, whose flow is also greatly modified by diversions. Satisfactory projections for this stream would require a special calculation using input specific to the area.

Results for the Trinity and Pearl rivers were also excluded, because both streams pass through flow control reservoirs in their lower reaches. Calculation of the effects of sediment retention and water residence time in these structures were impracticable within the present computer model.

Table 11 contains a calculation of the frequency with which the estimated concentrations exceeded the stated levels at the mouths of three selected rivers. Data for the Mississippi and Tombigbee are calculated over five and the Brazos over three years. These basins were selected to represent three different conditions -- the Brazos as principally a cotton growing area, with a relatively low soybean acreage in contrast to the Tombigbee where soybeans predominate. The Mississippi was selected as the geographically largest. Complete data, including cotton acreages, can be found in Falco et al., (1978).

CALCULATED RUN-OFF FROM FIELDS

The computed diflubenzuron concentrations discharged to the river from the cotton fields of the Yazoo basin under 1971 and 1973 weather patterns were found to be, assuming applications of 0.125 lb/AI/acre:

Table 11. Frequency of periods where estimated diflubenzuron concentrations exceeded stated levels for given durations over three or five year sequences (discharges from cotton only).[a]

Concentration	Duration (days)									
(ppb)	1	2	3	4	5	6-10	11-15	16-20	21-30	31-40	41-60
Mississippi (Five Years)											
1.0	2	2	2	2	1						
0.1	15	13	13	13	13	9	6	1	1		
0.01	15	13	13	12	12	11	10	7	6	3	1
Tombigbee (Five Years)											
1.0	5	5	5	5	4	4	3				
0.1	14	14	14	13	13	12	10	7	3	1	
0.01	15	15	15	15	15	15	14	9	6	4	1
Brazos (Three Years)											
1.0	6	6	5	3	2	2	2	1			
0.1	5	5	5	5	5	5	5	5	4	3	1
0.01	9	9	9	9	9	9	9	9	4	4	1

[a]from Falco et al. (1978).

	Year	
	1971	1973
Concentration range (ppb)	0.03 - 85	0.05 - 115
Mean	15	11
Median	1.5	4.0
Number of events	13	25

Comparison of these figures with those above reveals a wider range of predicted concentrations, probably reflecting the range of predicted volumes of run-off water. Allowing for the assumption that the earlier concentrations were based upon 2.5 cm of run-off, the agreement between the two sets of estimates are excellent, indicating that diflubenzuron concentrations in water directly discharged from cotton fields is likely to range from very low values to about 100 ppb. The difference between the median and mean values indicates that the latter are heavily weighted by relatively few high values and that concentrations will not exceed about 4 or 5 ppb during one half the events that take place.

Since diflubenzruon is adsorbed by sediments and a number of benthic organisms which may be affected are crustaceans, the concentration of diflubenzuron on sediments deposited in the estuaries may be important. A convenient approximate estimate of the concentrations (in ppm) on the sediments may be obtained by multiplying the concentrations of Table 10 by the

distribution coefficient (x 2000). This assumes that the sediment consists of 50% organic matter and the adsorption isotherm corresponds to that given by Carringer et al. (1975). The results of this calculation are given by Falco et al. (1978).

INTERPRETATION

The estimates show marked differences between river basins and also diferences reflecting the applications to soybeans. Highest estimated diflubenzuron concentrations and largest frequencies are indicated for the Nueces, Colorado, and Brazos rivers, suggesting that the largest imput of diflubenzuron is likely to be found in the estuaries of the rivers on the western Gulf Coast. While the analysis has not been performed, it is possible that this may reflect the greater sensitivity of the flow of these rivers to rainfall on the Coastal Plain. Estimated concentrations at the mouths of the Mississippi and Tombigbee are generally lower; this may perhaps reflect dilution of the diflubenzuron by run-off from a relatively greater proportion of untreated land. Complete interpretations of these differences will, however, depend upon full analysis of the factors used in the modeling projections.

In evaluating the diflubenzuron concentrations projected by the modeling process, it is essential that the uncertainties introduced by the basic assumptions should be borne constantly in mind. Three of these are of particular importance. All are likely to lead to overestimates of the amounts and concentrations of diflubenzuron transported away from the areas of application.

The assumption that the weather patterns over all the basins are always the same in time and intensity as those of Beeville, Texas, leads to the projection that run-off will tend to take place from all the fields in all the basins at the same time. This is clearly a condition that needs further study. Except for major

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storms of hurricane proportions, heavy summer rainfall in the cotton and soybean belts is most frequently associated with localized thunderstorms. While considerable run-off may occur in such storms, the active area at any one time will be a small fraction of the whole.

The model assumes that the entire cotton acreage is treated with diflubenzuron at uniform rates on an idealized schedule. This projection does not conform to normal use practices for pesticides. White much may be treated at once, large areas may be treated at lower rates or frequencies, further reducing the chances of large scale run-off of freshly applied material from the entire cropped area.

Thirdly, the model assumes that all run-off from the entire treated area is directly discharged to flowing streams for immediate continuous transport by rivers. No allowance is made for delays in movement over swales, ditches, or drainage systems, or for the retention capacity of these in holding back run-off for considerable periods of time. Major reductions in diflubenzuron concentrations will take place where this occurs due to adsorption on untreated soil and by chemical degradation during the delay. All these assumptions tend to increase the estimates of the amounts of diflubenzuron that may potentially be moved away from the target areas. In the absence of any observational data to validate the model, the size of the factors to correct them are unknown so that the estimates presented in Tables 9, 10, 11, and additional data in Falco et al. (1978) must be viewed with considerable reserve.

Modeling projections of the levels of diflubenzuron or any other pesticide that might be discharged by major river systems would need to be reserved until such projections are varified by valid, measured scientific parameters. In the case of diflubenzuron, there are no data indicating to what extent, if at all, the compound might leave the area of application via run-off, nor is there documented evidence that the proposed uses of diflubenzuron will

ong precipitation. Heavy summer rainfall in the cotton belt occurs as frequently associated with local and thunderstorms. When run-off may occur in such storms, the active area at any one time small fraction of the whole.

The model assumes that the entire cotton acreage is treated with toxaphene at uniform rates on an idealized schedule. This projection to practices for pesticides. While much may be treated, some areas may be treated at lower rates or frequencies.

...scale run-off of freshly applied material from the cotting growing area. Thirdly, the model assumes that all run-off from the total area is directly discharged to flowing streams for immediate continuous transport. No allowance is made for delays in movement over swales, ditches or systems, or for the retention capacity of these in holding run-off for periods of time. Major reductions in diffluence will take place where this occurs due to adsorption on sediments and by chemical degradation during the delay. All these assumptions lead to overestimates of the amounts of diffluence that may potentially move from the target areas. In the absence of any observational data on the model, the size of the factors to correct them are unknown. Estimates presented in Tables 9, 10, 11, and additional data in Faleo 1978, must be viewed with considerable reserve.

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... to date, indicating to what ... from the area ... ication ... run-off, ... the measured ... of diffluence which will

result in any residues being discharged into estuarine or salt water environments. Thus, the possibility that diflubenzuron may interact with any organisms in such environments needs at this point to be viewed as problematical.

EFFECTS OF DIFLUBENZURON ON NON-TARGET ORGANISMS BASED ON LEVELS PROJECTED AT THE MOUTHS OF RIVER BASINS BY MATHEMATICAL MODELS

Projected diflubenzuron concentrations at the mouths of several river systems draining cotton and/or soybean acreage were calculated using Version II of EPA Agricultural Run-off Management (ARM) Model (Donigan et al., 1977) as developed by Falco et al. (1978).

The present assessment excluded the effects of diflubenzuron on non-target aquatic organisms in the various river systems from the time that diflubenzuron entered the river systems as watershed run-off until it reached the mouth of the river systems. No predicted levels of diflubenzuron at various points down river from the point of entry were produced by the USEPA Model. Also, the assessment team did not have access to any literature relative to the effects of diflubenzuron on riverside species. The projected effects of diflubenzuron on non-target aquatic organisms at the mouths of the Mississippi, Atchafalaya, Tombigbee, Brazos, Nueces, and Rio, Grande Rivers were determined using the data obtained from the ARM model.

In assessment of the effects of diflubenzuron contained in water potentially moving through the various watersheds, the USEPA model assumed that the entire acreage of both cotton and soybeans would be treated. It is important to understand that: 1) no assumption was made in which partial treatment of this acreage would occur (under no circumstances would all of the cotton and soybean acreage be treated with diflubenzuron); 2) no consideration was made of the fact that the treated acreage would not receive applications of

diflubenzuuron on a more representative use schedule (it is known that differences in plant varieties, soil conditions, climatic conditions, and pest populations, as well as other varibles, could cause tremendous variations in the diflubenzuron application schedules); and 3) no assumption was made concerning the rate at which the potentially contaminated watershed water from the various river basins would mix with the sea water at the mouths of the river systems (the influence of tidal flow at the mouths of the rivers would be great relative to whether or not the contaminated river water remained in the main river channel or whether or not it was pushed and dispersed through the marsh areas on either side of the main channel at the mouth of the river).

Outflow of water from the marsh areas is also greatly influenced by wind speed and direction in that wind from the north tends to push water out of the marsh, while south winds tend to push water into the marsh or, in many cases, hold water in the marsh. Adequate reference has been included in a previous section regarding the USEPA models assumptions regarding weather conditions, stream flow data, and soil stability and hydrologic characteristics.

Following a review of the data reported on studies of diflubenzuron, the assessment committee agreed that 5 species of non-target aquatic organisms, if present in the habitat receiving water that contained diflubenzuron, would be sensitive to relatively low concentrations of the compound (0.2-2.0 ppb). The five species are : Mysid shrimp (*Mysidopsis bahia*), grass shrimp (*Palaemonetes pugio*), blue crab (*Callinectes sapidus*), marsh crab (*Sesarma reticulatum*), and brine shrimp (*Artemia salina*).

The data in Tables 12-15 show the combined data from the USEPA model and the published concentrations of diflubenzuron that effect the 5 non-target organisms indicated. The data in these tables need no explanation other than the fact that if, as the EPA model predicts, the listed concentrations of

n s me representing the schedule (it is known that differences

pecies, soil conditions, climatic conditions, and pest popu s, could cause tremendous variations in the diflubenzuron

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data in these tables need no explanation other than

the listed concentrations of

Table 12. Summer concentrations and effects of diflubenzuron on non-target aquatic organisms at the mouth of five river basins resulting from applications at maximum rates of 0.75 lb AI/acre/season to cotton and 0.125 lb AI/acre/season to soybeans.

Year	Concentration diflubenzuron in River water ppb A[a]	B[b]	Levels of diflubenzuron at which non-target organisms are affected (ppb): Mysid shrimp *Mysidopsis bahia* ≥0.2	Grass shrimp *Palaemonetes pugio* ≥0.45	Blue crab *Callinectes sapidus* ≥0.5	Marsh crab *Sesarma reticulatum* ≥1.0	Brine shrimp *Artemia salina* ≥2.0
Mississippi River Basin							
1971	1.1	0.69	X	X	X		
1972	0.49	0.30	X				
1973	0.63	0.39	X				
1974	0.34	0.21	X				
1975	0.25	0.16					
Atchafalaya River Basin							
1971	1.6	0.99	X	X	X		
1972	0.75	0.46	X	X			
1973	0.65	0.41	X				
Tombigbee River Basin							
1971	0.43	0.24	X				
1972	0.56	0.31	X				
1973	0.55	0.31	X				
1974	0.20	0.11					
1975	0.10	0.06					
Brazos River Basin							
1973	1.4	1.03	X	X	X	X	
1974	1.9	1.43	X	X	X	X	
1975	0.77	0.58	X	X	X		
Colorado River Basin							
1971	6.2	4.13	X	X	X	X	X
1972	5.6	3.73	X	X	X	X	X
1973	1.7	1.13	X	X	X	X	
1974	0.85	0.56	X	X	X		
1975	0.36	0.24	X				

[a]Data generated ARM-EPA lab, Athens, Ga. -- See Falco et al. (1978) (0.250 lb AI/acre for 4 applications at 7 day intervals). [b]ARM-EPA data corrected to show concentrations of diflubenzuron resulting from treatment of cotton and soybeans at maximum rates = combined rate of 0.875 lb AI/Acre/season

Table 13. Summer concentrations and effects of diflubenzuron on non-target aquatic organisms at the mouth of five river basins resulting from applications at expected application rates (Cotton - 0.475 lb AI/acre/season = 4 applications of 0.0938 lb AI/acre and soybean - 0.0625 lb AI/acre/season = 2 applications of 0.0312 lb AI/acre).

Concentrations diflubenzuron in River water ppb			Levels of diflubenzuron at which non-target organisms are affected (ppb)				
			Mysid shrimp *Mysidopsis bahia*	Grass shrimp *Palaemonetes pugio*	Blue crab *Callinectes sapidus*	Marsh crab *Sesarma reticulatum*	Brine shrimp *Artemia salina*
Year	A[a]	B[b]	≥0.2	≥0.45	≥0.5	≥1.0	≥2.0
Mississippi River Basin							
1971	1.1	0.34	X				
1972	0.49	0.15					
1973	0.63	0.19					
1974	0.34	0.11					
1975	0.25	0.08					
Atchafalaya River Basin							
1971	1.6	0.50	X	X	X		
1972	0.75	0.23	X				
1973	0.65	0.20	X				
Tombigbee River Basin							
1971	0.43	0.12					
1972	0.56	0.16					
1973	0.55	0.15					
1974	0.20	0.06					
1975	0.10	0.03					
Brazos River Basin							
1973	1.4	0.52	X	X	X		
1974	1.9	0.71	X	X	X		
1975	0.77	0.29	X				
Colorado River Basin							
1971	6.2	2.04	X	X	X	X	X
1972	5.6	1.84	X	X	X	X	
1973	1.7	0.56	X	X	X		
1974	0.85	0.28	X				
1975	0.36	0.12					

[a]from Falco et al. (1978). [b]ARM-EPA data corrected to show concentrations of diflubenzuron resulting from treatment of Cotton and Soybeans at expected use rate = combined rate of 7 oz AI/acre/season.

Table 14. Summer concentrations and effects of diflubenzuron on non-target aquatic organisms at the mouth of 7 river basins resulting from applications at the expected rates of application on cotton (0.75 lb AI/acre/season).

Year	Concentrations diflubenzuron in River water ppb A[a]	Concentrations diflubenzuron in River water ppb B[b]	Levels of diflubenzuron at which non-target organisms are affected (ppb): Mysid shrimp *Mysidopsis bahia* ≥0.2	Grass shrimp *Palaemonetes pugio* ≥0.45	Blue crab *Callinectes sapidus* ≥0.5	Marsh crab *Sesarma reticulatum* ≥1.0	Brine shrimp *Artemia salina* ≥2.0
Mississippi River Basin							
1971	0.53	0.40	X				
1972	0.23	0.17					
1973	0.29	0.22	X				
1974	0.16	0.12					
1975	0.12	0.09					
Atchafalaya River Basin							
1971	0.76	0.57	X	X	X		
1972	0.35	0.26	X				
1973	0.30	0.23	X				
Tombigbee River Basin							
1971	0.09	0.07					
1972	0.12	0.09					
1973	0.12	0.09					
1974	0.04	0.03					
1975	0.03	0.02					
Brazos River Basin							
1973	1.3	0.98	X	X			
1974	1.9	1.43	X	X	X		
1975	0.76	0.57	X				
Colorado River Basin							
1971	3.9	2.93	X	X	X	X	
1972	3.5	2.63	X	X	X	X	
1973	1.1	0.83	X				
1974	0.53	0.40	X				
1975	0.22	0.17					

Table 14. Continued

Concentrations diflubenzuron in River water (ppb)			Levels of diflubenzuron at which non-target organisms are affected (ppb)				
			Mysid shrimp *Mysidopsis bahia*	Grass shrimp *Palaemonetes pugio*	Blue crab *Callinectes sapidus*	Marsh crab *Sesarma reticulatum*	Brine shrimp *Artemia salina*
Year	A[a]	B[b]	≥0.2	≥0.45	≥0.5	≥1.0	≥2.0
Nueces River Basin							
1973	3.4	2.55	X	X	X	X	X
1974	2.2	1.65	X	X	X	X	
1975	3.2	2.4	X	X	X	X	X
Rio Grande River Basin							
1971	17	12.75	X	X	X	X	X
1972	1.3	0.98	X	X	X		
1973	0.62	0.47	X	X			
1974	1.1	0.83	X	X	X		
1975	0.04	0.03					

[a]Data generated ARM-EPA lab, Athens, GA. [b]ARM-EPA data corrected to show concentrations of diflubenzuron resulting from treatment of cotton at maximum rate (0.75 lb AI/acre/season) -- The use of 4 applications/season in the ARM model required the use of 4 applications of 0.1875 lb AI/acre at 7 day intervals rather than 6 applications of 0.125 lb AI/acre at 7 day intervals to attain the maximum amount of diflubenzuron (0.75 lb AI/acre) permitted per year.

Table 15. Summer concentrations and effects of diflubenzuron on non-target aquatic organisms at the mouth of 7 river basins resulting from applications at the expected rates of application on cotton (0.375 lb AI/acre/season).

Concentrations diflubenzuron in River water ppb			Levels of diflubenzuron at which non-target organisms are affected (ppb)				
			Mysid shrimp *Mysidopsis bahia*	Grass shrimp *Palaemonetes pugio*	Blue crab *Callinectes sapidus*	Marsh crab *Sesarma reticulatum*	Brine shrimp *Artemia salina*
Year	A[a]	B[b]	≥0.2	≥0.45	≥0.5	≥1.0	≥2.0
Mississippi River Basin							
1971	0.53	0.20	X				
1972	0.23	0.09					
1973	0.29	0.11					
1974	0.16	0.06					
1975	0.12	0.045					
Atchafalaya River Basin							
1971	0.76	0.28	X				
1972	0.35	0.13					
1973	0.30	0.11					
Tombigbee River Basin							
1971	0.09	0.035					
1972	0.12	0.045					
1973	0.12	0.045					
1974	0.04	0.015					
1975	0.03	0.01					
Brazos River Basin							
1973	1.3	0.49	X	X			
1974	1.9	0.71	X	X	X		
1975	0.76	0.29	X				
Colorado River Basin							
1971	3.9	1.46	X	X	X	X	
1972	3.5	1.31	X	X	X	X	
1973	1.1	0.41	X				
1974	0.53	0.20	X				
1975	0.22	0.08					

Table 15. Continued

Concentrations diflubenzuron in River water (ppb)			Levels of diflubenzuron at which non-target organisms are affected (ppb)				
			Mysid shrimp *Mysidopsis bahia*	Grass shrimp *Palaemonetes pugio*	Blue crab *Callinectes sapidus*	Marsh crab *Sesarma reticulatum*	Brine shrimp *Artemia salina*
Year	A[a]	B[b]	≥0.2	≥0.45	≥0.5	≥1.0	≥2.0
Nueces River Basin							
1973	3.4	1.28	X	X	X	X	
1974	2.2	0.82	X	X	X		
1975	3.2	1.20	X	X	X	X	
Rio Grande River Basin							
1971	17	6.38	X	X	X	X	X
1972	1.3	0.49	X	X			
1973	0.62	0.23	X				
1974	1.1	0.41	X				
1975	0.04	0.015					

[a]Data generated ARM-EPA lab, Athens, Ga. [b]ARM-EPA data corrected to show concentrations of diflubenzuron resulting from treatment of cotton at expected use rate (0.375 lb AI/acre/season) -- The rate of 4 applications in the ARM model has required the use of 4 applications of 0.0937 lb AI/acre rather than the expected use of 6 applications of 0.0625 lb AI/acre, to attain the total expected amount of diflubenzuron per year.

diflubenzuron did in fact arrive at the estuarine areas of the various river systems, a reduction in the listed organisms would occur as indicated in Tables 12-15.

Discussion is pertinent, however, when comparing the Model predictions for the various use rates on cotton and/or soybeans and the resulting potential effects on the non-target organism populations. Considerable difference exists between the effects of diflubenzuron on the non-target populations exposed to run-off water where the maximum amount of diflubenzuron requested for registration would be applied (as utilized by the USEPA Model stipulations) and that of the expected use rates. Mysid shrimp, due to their extreme sensitivity to diflubenzuron, would be affected during some years in all of the river systems, regardless of the use rate, except in the Tombigbee River where only the maximum use rate permitted by the cotton and soybean labels (0.875 lb AI/acre/season total for cotton and soybeans) caused effects. As diflubenzuron use rates were adjusted to the expected use rates for cotton and/or soybeans, the effects on the 5 non-target species were reduced in the Mississippi, Atachafalaya, and Tombigbee River Basins. However, all 5 non-target populations were affected to some extent during certain years in the Brazos, Colorado, Nueces, and Rio Grande River Basins, regardless of use rates.

From the scientific data available, it is clear that if the concentrations of diflubenzuron estimated by the USEPA Model were to be present in water reaching the mouths of the various rivers that certain non-target organism populations would be reduced. This effect would probably be quite severe if the data continued in the USEPA Model-frequency tables are representative. Prolonged exposure to diflubenzuron (past the time of acute affects and into time intervals of exposure causing chronic exposure effects) at the

did in fact arrive at the extraction point of the ... use ...

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...ussion is par... . However, ... the ... prescriptions ...

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...re adjusted to the expected use rates for cotton ...

... on the 5 non-target species were reduced in the Mississippi, ...

...alaya, and Tombigbee River basins. However, all non-target ...

...ted to some extent during certain years in the Brazos, ...

... Rio Grande River Basins, regardless of use rates.

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concentrations estimated by the USEPA Model might well temporarily eliminate total populations of some of these organisms from those habitats affected. This would depend on the species involved and the stage of life cycle in which the organism was at the time the exposure was initiated, as well as the time interval prior to change from one stage to the next stage. Long periods of exposure to diflubenzuron at the concentrations estimated by the USEPA Model would increase the probability of the organism opening its "activity window" for the natural hormone (growth regulator) process to proceed in the development of the organism. Therefore, diflubenzuron (its mode of action is involved with chitin inhibition) would be available for longer periods at concentrations sufficient to disrupt the natural and successful change from one developmental stage to the next. This event could place more importance on chronic effects than on the acute effects.

Therefore, it is of the greatest importance to completely understand and appreciate the uncertainties of the diflubenzuron concentrations that were projected by the USEPA Model. The following points must be evaluated along with any decision made relative to the exposure of non-target aquatic organisms to the projected concentrations of diflubenzuron contained in water at the mouths of the river systems:

1. Rarely, if ever, would climatic conditions be the same over the entire area contained in the river basins which could cause run-off from all treated fields at the same time.
2. For many reasons including economics it is highly improbable that all of the cotton and/or soybean acreage with a given river drainage basin would be treated with diflubenzuron. Recent USDA projected use patterns for diflubenzuron use on cotton and soybeans indicate that actual cotton and soybean acreages treated will not exceed about 15%

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many reasons including

and 5%, respectively, of the treated acreages assumed in the model.

3. It is also unlikely, due to economics and other reasons, that the treated acreages would receive the maximum rate permitted by the label. Most likely, the acreages treated would be at lower rates and at different frequencies due to variation in pest populations, planting dates, plant growth rates and climatic conditions.
4. Seldom, and certainly not in all the areas concerned, would run-off from treated acreage move directly and immediately into a river system. Rather, the usual situation would involve delays in water movement caused by various natural geographical features (movement through vegetation, changes in soil permeability and type, and areas of variable elevation) and man-made features (ditches, canals and other drainage systems). These delays in diflubenzuron movement into the major streams would result in major reductions in diflubenzuron concentrations through adsorption to soils, settling, and chemical breakdown.

Consideration of these assumptions in the USEPA model is most important in arriving at a reasonable estimate of what might occur as a result of contaminated water run-off. It must be emphasized that the available experimental data on the run-off potential of diflubenzuron (both laboratory and field studies) suggest that this compound will be subject to, at most, very minimal run-off. Thus, there is currently no indication that the proposed uses of diflubenzuron will result in any residues being discharged into estuarine or salt water environments, and the possibility that diflubenzuron may interact with any organisms in such environments must at this point be considered problematical.

and 5%, respectively, of the treated acreage present in the ...

... also unlikely, due to economic and other reasons, that the treated acreages would receive the maximum rate permitted by the label.

... likely, the ... treated would be at ... different frequencies due to variation in pest population, ... dates, plant growth rates and climatic conditions.

Seldom ... certainly not in all the areas ... would run-off from treated acreage move directly and immediately into ... river ... Rather, the usual situation would involve delays in water movement caused by various natural geographical features (e.g., vegetation, changes in soil permeability and type, and areas of variable elevation) and man-made features (ditches ... drainage systems). These delays in diflubenzuron movement into streams would result in major reductions in diflubenzuron concentrations through adsorption to soils, ... and ... breakdown.

... consideration of these assumptions in the USEPA model ... a reasonable estimate of what might occur as a result of ... water run-off. It must be emphasized that the ... data on the run-off potential of diflubenzuron (both ... lies) suggest that this compound will be subject to ... run-off. Thus, there is currently no indication that the proposed use ... will result in any ... is being ... the possibility that diflubenzuron ...

Finally, consideration must be given to the comparison of diflubenzuron with other chemicals that are used as alternatives. In most cases, the effects of diflubenzuron on non-target organisms are considerably less than those of alternative compounds due to diflubenzuron's characteristics of lower rates of application required to control target species, short residual life, less effects on non-target organisms, and less hazard to human applicators.

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or non-target organisms, and less hazard to [illegible]

HUMAN EXPOSURE: DIETARY

Human dietary exposure projections were made based on three possible sources of dietary intake of diflubenzuron residues: direct consumption of cotton or soybean seed and their processed fractions, consumption of meat, milk, and eggs from livestock and poultry fed cottonseed and/or soybean seed fractions from treated crops, and consumption of fish from diflubenzuron-contaminated waters. Cottonseed and soybean seed can be considered to be the only significant sources of dietary exposure of livestock to diflubenzuron residues, because label restrictions prevent grazing treated fields or pastures, or feeding treated cotton or soybean foliage. As will be discussed below, current projected uses of diflubenzuron in mosquito control and for the control of certain forest insects are not likely to result in any significant human dietary exposure.

In developing the exposure profiles, a "worst case" situation was assumed in which cottonseed and soybean residues were projected to approach levels as high as the minimum sensitivity of the analytical enforcement method (0.05 ppm). This approach assumes residues in treated crops at levels clearly higher than those likely to be seen under normal insect control practices, because numerous residue studies in cottonseed and soybeans have shown that "real world" residues are almost always <0.05 ppm in the whole or processed seed. In making the projections under the "worst case" scenario, it was also assumed that <u>all</u> cottonseed and soybean food or feed products were derived from diflubenzuron-treated crops, whereas in reality, < 15% and < 5% each of the total cotton and soybean acreages, respectively, are likely to receive any diflubenzuron treatments at all under the proposed cotton and soybean registrations.

HUMAN EXPOSURE: DIETARY

[illegible] dietary exposure projections were made based on three possible [illegible] of dietary intake [illegible] diflubenzuron residues: direct consumption [illegible] soybean seed and their processed fractions, consumption of meat, milk [illegible] livestock and poultry fed cottonseed and/or soybean [illegible] [illegible] [illegible]ed crops, and consumption of fish from diflubenzuron-contaminated [illegible]

Cottonseed and soybean seed can [illegible] considered to be the only [illegible]ant sources of dietary exposure of livestock to diflubenzuron [illegible] label restrictions prevent grazing treated fields or pastures [illegible] [illegible] fed cotton or soybean foliage. As will be discussed below, [illegible] uses of diflubenzuron in mosquito control and for the control [illegible] forest insects are not likely to result in any significant human dietary [illegible]

[illegible] eloping the exposure profiles, a "worst case" situation was [illegible] cottonseed and soybean residues were projected to approach levels [illegible] the minimum sensitivity of the analytical enforcement method (0.05 ppm), [illegible]ch assumes residues in treated crops [illegible] levels clearly higher than [illegible]ly [illegible] be seen under normal insect control practices, because [illegible] [illegible]dies in cottonseed and soybeans have shown that "real world" [illegible] [illegible] always <0.05 ppm in the whole or processed seed. In making the [illegible] [illegible]st case" scenario, it was also assumed that all [illegible] [illegible]ducts were derived from diflubenzuron- [illegible] [illegible] [illegible] each of the total cotton and [illegible] [illegible] to receive [illegible] [illegible]

COTTON AND SOYBEANS

Direct Human Exposure. The human population can be expected to receive direct dietary exposure to diflubenzuron residues through consumption of cottonseed and soybeans and their processed fractions. However, a review of residue data revealed that residues in whole or processed cottonseed and soybeans will, in all cases be <0.05 ppm. Direct utilization of cottonseed and soybean products as human food sources comprise at present only a minor proportion of the human diet and thus direct dietary exposure of humans via these sources is projected to be very minimal. Food factor tables from Lehman (1962) indicate that the typical human diet contains about 0.15% and 0.92% of cottonseed and soybean fractions, respectively. Thus, the "worst case" intake of diflubenzuron residues from direct consumption of cottonseed and soybean fractions can be calculated to be 0.00000188 mg/kg/day (cottonseed) and 0.00001150 mg/kg/day (soybeans) (Table 16).

The consumption of infant formulas represents a situation in which dietary exposure to diflubenzuron residues of a specific portion of the human population may occur. Certain infant formulas contain soybean oil and/or soy protein, but it is not believed that cottonseed fractions are used in infant formulas to any significant extent, if at all. Based on published information (Barness et al., 1976), it was assumed for the current assessment that such formulas might contain a maximum of 5% total soybean fractions (oil and protein). Thus, a 7 kg infant, consuming 0.68 kg (1.5 lbs) of formula/day, could conceivably consume as much as 0.034 kg total soy fractions (0.68 x 0.05). If the soy fractions contained 0.05 ppm diflubenzuron, the total diflubenzuron intake would be 0.0017 mg diflubenzuron/ 7 kg infant/day (0.034 x 0.05) or 0.00024 mg/kg/day.

Food Chain Exposure. Whole cottonseed and soybeans and their various fractions are commonly used as components of livestock and poultry feeds, and

[illegible] Human Exposure. The human population can be exposed [illegible] exposure to diflubenzuron residues through consumption [illegible] soybeans and [illegible] processed fractions. However, a review of [illegible] that residues in whole or processed cottonseed and soybeans [illegible] be <0.05 p.p.m. Direct utilization of cottonseed and soy [illegible] sources comprise [illegible] present only a minor proportion of [illegible] diet, and thus direct dietary exposure of humans via [illegible] to be very minimal. Food factor tables from [illegible] (1977) [illegible] typical human diet contains about 0.15% and 0.[illegible] of [illegible] [illegible] fractions, respectively. Thus, the worst case intake of diflubenzuron from direct consumption of cottonseed and soybean fractions [illegible] [illegible] to be 0.00000168 mg/kg/day (cottonseed) and 0.0000112 [illegible] [illegible] Table 15).

[illegible] consumption of infant formulas represents a situation [illegible] diflubenzuron residues of a specific portion of the human population [illegible] Certain infant formulas contain soybean oil and/or soy protein, [illegible] [illegible] that cottonseed fractions are used in infant formulas to any extent, if at all). Based on published information (Barness et al. [illegible] [illegible] assumed for the current assessment that such formulas might [illegible] of [illegible] soybean fractions (oil and protein). Thus, [illegible] 0.08 [illegible] (3.5 lbs) of formula/day, could conceivably contain [illegible] [illegible] (0.08 x 0.05). If the soy fractions [illegible] [illegible] diflubenzuron intake would be 0.0017 [illegible] [illegible] x .05, or 0.00024 mg/kg/day.

[illegible] exposed by [illegible] youths and their parents [illegible] [illegible] and [illegible]

Table 16. "Worst case" projections of human dietary intake of diflubenzuron residues from food sources that may potentially contain diflubenzuron residues as a result of its use as an insecticide on cotton, soybeans, forests, and for mosquito control.

Human Food Source	% of Diet	Projected maximum residue present (mg/kg)	Specific commodity intake (kg food/ 60 kg person)[h]	Maximum difl. intake (mg dif/ 60 kg person/day)	Maximum difl. intake (mg dif/kg body weight/day)
Cottonseed	0.15	0.05	0.00225	0.00011250	0.00000188
Soybeans	0.92	0.05	0.0138	0.00069000	0.00001150
Meats, red	10.81	0.00001	0.16215	0.00000162	0.00000003
Milk and dairy products	28.62	0.000008	0.4293	0.00000340	0.00000006
Fish and shellfish	1.08	0.05	0.0162	0.00081000	0.00001350
Poultry	2.94	0.001	0.0441	0.00004410	0.00000074
Eggs	2.77	0.001	0.04155	0.00004155	0.00000069
			Total	0.00170317	0.00002840

[a]Estimates from Lehman, (1962). [b]Lower limit of sensitivity of analytical enforcement method. [c]Possible average "worst case" residue for edible tissues of red meat producing animals (see Table 20). [d]See Table 20. [e]Based on 50x magnification of residues from water containing 0.001 ppm diflubenzuron (see text). [f]Possible average. [h]Based on 1.5 kg food intake/day/60 kg person.

they may comprise a considerable proportion of the total diet of these animals. Assuming a "worst case" situation where diflubenzuron residues in these two commodities reached 0.05 ppm, estimation can be made of the maximum dietary exposure of various food producing animals to diflubenzuron residues from consumption of seed or seed products. These estimates are given in Table 17.

The estimates in Table 17 indicate that broiler chickens and turkeys have potential for exposure to higher levels of diflubenzuron residues than other food animals, due to a combination of high feed intake during their active growth stage and relatively high levels of cottonseed and/or soybean fractions in their diets. The calculations indicate that exposure of red meat and milk producing animals, and laying hens, to diflubenzuron residues through these feed sources will be quite low (Table 17).

Residue Projections: Cattle. On the basis of residue and metabolism studies with diflubenzuron in cattle, and on maximum projected dietary exposure to diflubenzuron residues through consumption of contaminated cottonseed and soybeans, "worst case" estimates of residues expected in meat and milk resulting from the cotton and soybean registrations were made. Long-term feeding studies with diflubenzuron in lactating cattle have been conducted by Miller et al. (1976) and Smith and Merricks (1976) in which experimental conditions allowed plateau levels of residues in milk and tissues to be reached. In each case, secretion of residues into milk and their retention by edible tissues was very low. Appropriate findings from these studies are summarized in Table 18.

Based on "worst case" exposure of cattle to diflubenzuron residues *via* cottonseed or soybeans (Table 17) and the residue patterns observed in the "reference" studies by Miller et al. (1976) and Smith and Merricks (1976) in cattle feeding studies with diflubenzuron (Table 18), the maximum projected

species: considerable proportion of the total diet of these animal

a "worst case" situation where diflubenzuron residues in these two

s reached 0.05 ppm, estimation can be made of the maximum dietary

of various food ing animals to diflubenzuron residues from

of seed or seed products. These estimates are given in Table 17.

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to higher levels of diflubenzuron residues than

imals, due to a combination of high feed intake during

stage and relatively high levels of cottonseed

diets. The calculations indicate that exposure

animals, and laying hens, to diflubenzuron residues through

will be quite low (Table 17).

ue Projections Cattle. On the basis of residue

with diflubenzuron in cattle, and on maximum projected dietary exposure

on residues through consumption of contaminated

, "worst case" estimates of residues expected in meat and milk

cotton and soybean registration were made. Long-term

ubenzuron in lactating cattle have been conducted by Miller et al.

Smith and Merricks (1976) in which experimental conditions allowed

vels residues in milk and tissues to be reached. In

of residues into milk and their retention by edible tissues

ate findings from these studies are summarized in Table 18.

worst case" exposure of cattle to diflubenzuron residues via

s (Table 17) and the residue patterns observed in the

Miller et al. (1976) and Smith and Merricks (1976)

on (Table 18), the maximum

Table 17. Estimates of maximum dietary exposure of livestock and poultry to diflubenzuron residues from consumption of cottonseed and soybean fractions.

Animal	Maximum Seed Residues ppm C	Maximum Seed Residues ppm S	Seed in Diet, % C	Seed in Diet, % S	Maximum Diflubenzuron Residues, ppm Total Diet C	Maximum Diflubenzuron Residues, ppm Total Diet S	Feed Consumption % Body wt/day	Maximum Diflubenzuron Body Weight mg/kg/day C	Maximum Diflubenzuron Body Weight mg/kg/day S
Cattle, beef	0.05	0.05	15	15	0.008	0.008	1.5	0.00012	0.00012
Cattle, dairy	0.05	0.05	15	25	0.008	0.012	1.5	0.00012	0.00018
Hogs	0.05	0.05	5	20	0.0025	0.010	4.0	0.0001	0.0004
Horses	0.05	0.05	15	20	0.008	0.010	2.0	0.00016	0.0002
Lambs	0.05	0.05	20	15	0.01	0.008	4.0	0.0004	0.00032
Chicken, broilers	0.05	0.05	10	25	0.005	0.012	12.0	0.0006	0.00144
Chicken, laying hens	0.05	0.05	3	35	0.0015	0.018	6.0	0.00009	0.0011
Turkeys	0.05	0.05	10	25	0.005	0.012	12.0	0.0006	0.00144

[a]Lower limit of sensitivity of analytical enforcement method for diflubenzuron. [b]Estimate from Harris, 1975. [c]Estimate from Lehman, 1965. [d]Estimate from Clark et al., 1978.

Table 18. Summary of long-term feeding studies with diflubenzuron in cattle.

Study	Dose Level mg/kg/day	Duration weeks	Maximum residue levels, ppm Milk	Muscle	Liver	Kidney	Fat
Miller et al., (1976)	16.0	12	0.02	ND	0.1	ND	0.2
Smith and Merricks, (1976)	0.075	4	0.005	.04	0.54	0.04	0.04

[a]Non-radioactive study. [b]Radioactive study. [c]Equivalent to 5.0 ppm dietary feeding level. [d]Residues not detected.

residues in milk and edible tissue were calculated by the following proportional scheme:

$$\frac{\text{Reference study treatment level, mg/kg/day}}{\text{Observed tissue residue, ppm}} \text{ as } \frac{\text{Maximum anticipated diflubenzuron exposure, mg/kg/day, Table 18}}{\text{(projected tissue residue, ppm)}}$$

These calculations of necessity assume that pharmacodynamics of the crop residues in animals (whether unmetabolized diflubenzuron, its metabolites, or a mixture thereof) approximate that of the parent compound administered directly. They are also based on an assumed direct dose-response relationship as regards residues in tissue and milk. The results of these projections for cattle tissues and milk are shown in Table 19 for both cottonseed and soybean residue sources.

As the data in Table 19 indicate, even under "worst case" exposure of cattle to cottonseed or soybeans from treated crops, levels to be expected in milk and edible tissues are exceedingly low, almost always in the sub-part per billion range. Comparisons of the projected residues calculated using either of the two "reference" studies reveal only two noticeable inconsistencies, namely the levels of residues projected in milk and liver (Table 19). Milk residue projections based on the Smith and Merricks study are about 50-fold higher than those based on studies by Miller and co-workers, while liver residue projections from the Smith and Merricks data are fully 3 orders of magnitude greater than liver residues calculated using the Miller et al. study as a model. It seems almost certain that these differences can be partially if not wholly explained by the fact that the Smith and Merricks study utilized radioisotope labeled diflubenzuron, which allowed quantitation of both diflubenzuron and its

in   lk and edible tissue were calculated by the following proportion:

nce study treatment level,   Maximum anticipated diflubenzuron exposure,
mg/kg/day   as   mg/kg/day, Table 18
tissue residue, ppm   (projected tissue residue, ppm)

culations of necessity assume that pharmacodynamics in test
in animals (whether unmetabolized diflubenzuron, its metabolites,
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Table 19. Maximum diflubenzuron residues projected in milk and edible tissues of cattle fed cottonseed or soybeans from treated crops.

Cattle Tissue	Maximum calculated residue, ppm, based on indicated reference study	
	Miller et al. (1976)	Smith and Merricks, (1976)
Cottonseed Exposure		
Milk	0.0000002	0.000008
Muscle	0.00000075	0.000006[a]
Liver	0.00000075	0.00036
Kidney	0.00000075	0.000006[a]
Fat	0.0000015	0.000006[a]
Soybean Exposure		
Milk	0.0000002	0.00001
Muscle	0.000001[a]	0.0001
Liver	0.000001	0.001
Kidney	0.000001[a]	0.0001[a]
Fat	0.000002	0.0001[a]

[a]Lower limit of projected residue, due to sensitivity of the analytical method used.

metabolites, while the Miller study employed unlabeled diflubenzuron and thus only the unmetabolized parent compound was detected. It is known that diflubenzuron metabolites comprise a considerable proportion of the total residue in milk (Ivie, 1978a; Smith and Merricks, 1976), and that the great majority of diflubenzuron residues in animal liver are primarily metabolic products and not intact diflubenzuron (Ivie, 1978b).

Poultry. Sufficient residue and metabolic fate data on diflubenzuron in poultry are available to permit projections of "worst case" tissue and egg residues to be anticipated after consumption of feeds containing cottonseed or soybean fractions. The calculations were made in the same manner as for cattle above, using data in Table 17 for estimates of maximum levels of cottonseed and soybean products in poultry feed. Estimates of maximum exposure of birds receiving diflubenzuron residues *via* dietary sources were made (Table 17), then the maximum tissue and egg residue profiles were developed on the basis of the two long term feeding studies with diflubenzuron in poultry that are summarized in Table 20. Based on the data in Table 20, projected residues in meat and edible tissue of poultry fed diets containing cottonseed or soybeans from treated crops were made. These projections are shown in Table 21.

Examination of the data in Table 21 indicates that, as with cattle, projected residues in poultry and eggs after consumption of diets containing cottonseed or soybean fractions were quite low. In all cases, projected residues were in the low or sub-ppb range. It does appear that, based on maximum utilization of cottonseed and soybeans in poultry feed (Table 17), growing chickens and turkeys fed cottonseed fractions in their diets are likely to exhibit tissue residues up to an order of magnitude greater then laying hens. This is because of considerably greater feed consumption on the part of broiler chickens and growing turkeys as compared to laying birds, and the fact that

While the Miller study employed [illegible] diflubenzuron [illegible]
metabolized parent compound was detected. It is known that
uron metabolites comprise a considerable proportion of the total
milk (Ivie, 1978a; Smith and Merricks, 1975) [illegible]
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s to be anticipated after consumption of feed [illegible] cotton
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s compared to laying birds, and the fact that

Table 20. Summary of long-term feeding studies with diflubenzuron in laying hens.

	Dose Level	Duration	Maximum residue level, ppm				
Study	mg/kg/day	weeks	Eggs	Muscle	Liver	Kidney	Fat
Miller et al., (1975)	0.10	3	0.05	-	-	-	-
Smith (1976)	.003	4	0.003	.001	.003	.003	.003

[a]Non-radioactive study. [b]Radioactive study. [c]Equivalent to 1.6 ppm dietary feeding level. [d]Equivalent to 0.05 ppm dietary feeding level.

Table 21. Maximum diflubenzuron residues projected in milk and edible tissues of poultry fed cottonseed or soybeans from treated crops.

	Maximum calculated residue, ppm, based on indicated reference study			
	Miller et al. (1975)		Smith (1976)	
Poultry tissue	broilers/turkeys	laying hens	broilers/turkeys	laying hens
Cottonseed Exposure				
Eggs	-	0.000045	-	0.00009
Muscle	-	-	0.00026	0.00003
Liver	-	-	0.0006	0.00009
Kidney	-	-	0.0006	0.00009
Fat	-	-	0.0006	0.00009
Soybean Exposure				
Eggs	-	0.00055	-	0.0011
Muscle	-	-	0.00048	0.00036
Liver	-	-	0.0014	0.0011
Kidney	-	-	0.0014	0.0011
Fat	-	-	0.0014	0.0011

[a]Tissue residues not determined in studies of Miller et al. (1975).

cottonseed fractions may comprise a considerably greater proportion of the total diet of growing versus laying birds (Table 17). Projected maximum poultry tissue residues in broiler and laying birds fed soybean-containing diets are much more comparable because of the relative proportions of soybeans likely to be included in broiler versus laying feed (Table 17).

Other Food Animals. The preceeding projections of maximum exposure and residue profiles expected in cattle and poultry as a result of the cotton and soybean registrations are useful in projecting anticipated residues in other food animals whose diets contain cottonseed or soybean fractions (Table 17). The actual projections for these animals, including swine, sheep, horses, and others, were not made because appropriate residue and/or metabolism data were limited or unavailable. However, there is no reason to believe that residue profiles for other red meat and milk producing animals, and other poultry, will differ appreciably from the profiles generated in Tables 19 and 21. Although residue profiles in ruminants are often not considered to be representative of other red meat producing animals due to the somewhat unique metabolic capabilities of the rumen itself, in the case of diflubenzuron, the rumen cannot be considered a complicating factor. Metabolism studies by Ivie (1978a) have conclusively shown that diflubenzuron is metabolically stable within the alimentary tract of ruminants.

Because fish comprise a significant portion of the human diet, they must be considered as a potential dietary source of diflubenzuron residues. However, based on the projected use patterns for diflubenzuron, it would appear that the potential for fish accumulating significant residues of the compound are quite low. It seems possible that, through run-off, drift or a combination thereof, water concentrations of diflubenzuron as high as 0.001 ppm might, on occasion,

growing versus laying bird. (Table 17). Predicted maximum

in broiler and laying birds fed soybea

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in broiler versus laying feed (Table 17).

r Food Animals. The preceeding projections of maximum exposur

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be sustained over a period of at least a few days (see "Non-Target Aquatics Exposure" section). If such were the case, residues in fish meat might reach levels approaching 0.05 ppm, assuming a biomagnification of 50x. The 50x level of potential biomagnification of diflubenzuron by fish seems an appropriate assumption on the basis of available information (Apperson et al., 1978; Booth et al., 1976; Schaefer et al., 1978). In projecting residues of diflubenzuron in fish, it is important to note that, although fish are capable of limited biomagnification of diflubenzuron from water, appreciable water contamination from the proposed diflubenzuron uses should be infrequent, the compound itself is not highly persistent in water (Schaefer and Dupras, 1976), and fish are capable of rapidly depleting residues of diflubenzuron from the body once exposure to the compound is terminated (Booth et al., 1976; Schaefer et al., 1978). Thus, the potential for significant human dietary exposure to diflubenzuron *via* residues in fish would appear to be very minimal.

EXPOSURE FROM USES AGAINST MOSQUITOES

Proposed Label. The proposed label excludes application on crops or in areas used for food, feed, hay, pasture, or for potable water, livestock watering or for crop production. Inasmuch as these restrictions would eliminate over 95% of the habitats where mosquito abatement districts would utilize diflubenzuron, only a very small amount of this compound could be used. In addition, such use would be in locations where neither man nor animals utilized for food would be exposed, and thus human exposure *via* the dietary route as a result of diflubenzuron use in mosquito control would be essentially nil.

Expanded Label. Should an additional label be requested and approved for the use of diflubenzuron on lands used for grazing livestock or growing

feed, much larger acreages would be treated for mosquito larvae. If the 25 WP formulation of diflubenzuron were dispersed in aqueous spray, within the 0.025 to 0.04 lb AI/acre range, initial residues in 4-6" deep water would be 0.03 ppm or less and 4 ppm or less on vegetation (Schaefer and Dupras, 1976).

If cattle were held on treated fields and fed continuously on grass containing 4 ppm diflubenzuron, the residues for milk and tissues are projected in Table 22. From the projections in Table 22, it appears that in such an exposure situation, the liver of the grazing animals might well exhibit total residues in excess of the sensitivity level of the analytical enforcement method.

Cattle are not normally held on flooded pastures, but if they were exposed continuously to water supplies in treated fields, and this water contained the highest expected diflubenzuron residues (0.03 ppm, Schaefer and Dupras, 1976), residues projected in milk and tissues would be at least an order of magnitude less than those indicated in Table 22, since maximum daily intake from water would not exceed 0.003 mg/kg/day.

The problems of livestock exposure to residues on vegetation following application of aqueous sprays of diflubenzuron can be essentially eliminated by using granular formulations. It is anticipated that diflubenzuron residues in water would not vary appreciably between the WP and granular formulations (Schaefer and Dupras, 1977), thus, granular applications offer a means of achieving mosquito control and simultaneously minimizing exposure of grazing stock to diflubenzuron residues.

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Table 22. Maximum diflubenzuron residues projected in milk and edible tissues of cattle fed pasture grass containing 4 ppm diflubenzuron.

Cattle Tissue	Maximum calculated residue, ppm, based on indicated reference study	
	Miller et al. (1976)	Smith and Merricks, (1976)
Milk	0.00008	0.004
Muscle	0.0004[a]	0.032[a]
Liver	0.0004	0.43
Kidney	0.0004[a]	0.032[a]
Fat	0.0007	0.032[a]

[a]Lower limit of projected residue due to sensitivity of the analytical method used.

Maximum dithiopyr residues predicted in milk and edible [illegible] fed pasture grass containing [illegible] ppm dithiopyr.

Maximum calculated [illegible]

Miller et al. (1976)	[illegible]
0.00003	[illegible]
0.0001	[illegible]

a [illegible] limit of expected residue due [illegible]

EXPOSURE FROM USES AGAINST FOREST INSECTS

The use of diflubenzuron to control the gypsy moth in hardwood forests and the tussock moth in coniferous forests would appear to create little likelihood for significant human dietary exposure. Although consumption of fish and game taken from treated areas might result in some intake of diflubenzuron, this would probably be infrequent and the exposure would likely be at extremely low levels. Wild fruits, nuts, berries, etc. might also be a medium through which very low levels of diflubenzuron would enter the human food chain as a result of diflubenzuron's use in forest insect control.

PROJECTION OF TOTAL HUMAN DIETARY EXPOSURE

Based on the calculations above, it is possible to calculate "worst case" estimates of daily human dietary intake of diflubenzuron residues. These projections (Table 16) are shown both as mg diflubenzuron/day for a 60 kg person, and as mg/kg/day. As the table indicates, these "worst case" estimates project that human dietary exposure to diflubenzuron from all food sources will be at an extremely low level, not exceeding 0.00002840 mg diflubenzuron/kg body weight/day. The projections obtained in these calculations are almost certainly much higher than those likely to be encountered in a real-world situation. Based on the fact that diflubenzuron will be used on only relatively small portions of the cotton and soybean acreages, and that residues in the seeds of these crops may be considerably below the 0.05 ppm sensitivity limit of the analytical enforcement method, it seems likely that average human dietary exposure will be much less, perhaps 1/10 - 1/100, of the "worst case" projections presented here.

RON USES AGAINST FOREST INSECTS

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HUMAN EXPOSURE: APPLICATORS, FIELD WORKERS, BYSTANDERS

COTTON

Formulation and Use Patterns. A wettable powder formulation of diflubenzuron (Dimilin W-25) containing 25% active ingredient will be used in cotton applications. The diflubenzuron in the WP formulation has a particle size distribution ranging from 2-5 μ and the formulation is packaged in 5 pound bags and 25 pound fiber drums.

Diflubenzuron will be applied to cotton at 0.0625 or 0.125 lb AI/acre as an aqueous spray for control of the boll weevil. A maximum of 0.75 lb AI/acre/season is permitted, thus limiting the number of applications. About 90% of the diflubenzuron used on cotton will be applied by fixed-wing aircraft and the remainder by tractor-drawn boom sprayer. One-fourth to one-half pound of the Dimilin W-25 is mixed with 2-4 quarts of emulsifiable paraffinic crop oil and then with at least 2 parts additional water for each part of oil. Aerial application is made using a total volume of 1-3 gallons/acre and ground applciations involve 5-30 gallons/acre. Detailed parameters for fixed-wing aircraft application of diflubenzuron to cotton are indicated in Table 23.

Under the current EUP approved for cotton by the USEPA, a total of 2,500 acres are allowed to receive diflubenzuron treatment. If a single aerial applicator treated all permitted acres, the swath exposure time per application would be 5 hours. Assuming 6 applications per season at 7-day intervals, the in-swath exposure time would be about 30 hours. If it were assumed that there would be one applictor per state where the EUP is permitted, this would represent 12 applicators with an average in-swath exposure of about 25 hours per applicator per season.

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uron (Dimilin W-25) containing 25% active ingredi[illegible]

[illegible]ications. The diflubenzuron in the [illegible]

[illegible]ibution ranging from 2-5 and the formulation [illegible]

15 pound filler dusts.

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permitted, thus limiting the number of [illegible]

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[illegible] tractor-drawn boom sprayer. One-fourth [illegible] one-half

[illegible] is mixed with 2 [illegible] emulsifiable [illegible]

[illegible] least 2 parts [illegible]

[illegible] made using a total volume of 1-3 gallons/acre [illegible]

[illegible] involve 5-30 gallons/acre. [illegible] for [illegible]

[illegible]ication of diflubenzuron to cotton are indicated in [illegible]

[illegible] the current EUP approved for cotton by the USEPA, [illegible]

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treated all permitted acres, [illegible]

hours. Assuming 6 applications per season at 7-day [illegible]

exposure time would be about 30 hours. If it were assumed that

[illegible]ctor per [illegible] where the EUP is permitted, this would

[illegible]ers with an average in-swath exposure of about 25 hours

Table 23. Parameters for fixed-wing aircraft application of diflubenzuron to cotton.

Formulation	W25 wettable powder
Equipment	Fixed-wing aircraft
Representative nozzle	Teejet 8006, fan spray
Flying speed	120 mph
Boom pressure	20 psi
Altitude	5-10 feet
Application rate	1-2 ounces AI/acre
Volume of application	1-3 gallons
Frequency of application	7-day interval
Number of applications/season	6
Hours spent in flying/day	4-5
Hours spent in spray swath/day	1
Average length of spray swath	1/2 mile
Average width of spray swath	40 feet
Average acres treated per day	500
Average acres treated/week	2,500
Average acres treated/season/pilot	21,000
Protective clothing	Coveralls and gloves
Number of pilots involved in EUP	12
Number of mixer/loaders	12
Number of pilots involved in full use program	66
Number of mixer/loaders involved in full use program	66
Number of applicators involved in ground applications (10% of acreage)	1185
Number of mixer/loaders involved in ground application (10% of acreage)	0

Regarding the full label registration on cotton, the percent of acres treated aerially will not change. The exposure study group for diflubenzuron has projected the potential treated acres in the United States for boll weevil to be 1,540,000. Assuming an average of 6 applications per season, this represents 9,240,000 acre treatments per season. If the average flying time per day is considered to be 5 hours, the actual in-swath time will average about 1 hour. Thus, each aerial applicator will spray about 500 acres/day or 3,500 acres on a 7-day repeat spray schedule. Calculating acre treatments per season, this would total 21,000 acres per applicator (3500 x 6). If it is assumed that 1,540,000 acres receive the 6 applications, 440 applicators will be required (9,240,000 ÷ 21,000).

Assuming that conditions outlined in Table 24 are representative, a protocol for the measurement of dermal and inhalation exposure of the mixer/loader can be developed. Assuming a volume/acre of 1 gallon of diflubenzuron solution and the applicator treats 500 acres/day, the 500 gallon mixing unit would meet the needs for a full day's operation. Mixing this volume of spray solution daily would eliminate the concern of leaving excess in the mix unit overnight, when the wettable powder would separate and require additional agitation time the following morning to be confident of a uniform mix.

Under the above operating conditions, the mixer/loader would add 125 pounds of Dimilin W-25 to the mixing tank in the process of filling it with the carrier (water). The total exposure time for weighing, mixing, and loading would not exceed 40 minutes.

Assumptions. The following assumptions were made to permit calculation of diflubenzuron exposure resulting from its application to cotton.

Table 24. Mixer/loader information for aerial application of diflubenzuron to cotton.

Capacity of mixing or nurse tank	500 gallons
Volume of diflubenzuron solution applied/acre	1 gallon
Acres treated/day/applicator	500
Rate of diflubenzuron (AI/Acre)	0.0625 lb AI
Number of applications/season	6
Load capacity of plane spray tank	150 gallons
Volume of transfer pump on mixing unit	15 gal/minute
Number of mixer/loaders required	440

A. Mixer/loaders will receive their primary exposure to diflubenzuron by contact with the dust. Respiratory exposure will be primarily during the actual bag opening/powder pouring operation. Estimated time of exposure per bag opening (5 lb bag) is 10 seconds. The amount of respirable Dimilin W-25 dust in the air is estimated to be 10 mg/m^3 during this operation.

B. Dermal exposure of mixer/loaders to Dimilin W-25 is also primarily associated with the short-term bag opening operation. However, the only experimental data available (Jegier, 1964) is for "tank-filling operation," which apportions the exposure over the entire mixing/loading time span. Jegier's estimate is 52.9 mg/hour for a 25% Guthion wettable powder.

C. Tank filling requires 40 minutes per day to mix and transfer 4 batches of 150 gallons each when either aerial application or boom spray treatment is involved. Only one mixer/loader is assumed per treatment operation.

D. No flagmen will be utilized.

E. No bystanders will be permitted to be directly exposed beneath the spray swath. Spray areas will be posted to assure adherence to this restriction.

F. Post-treatment scouting and cultural activities in the field are not expected to result in substantial respiratory or dermal exposure.

G. Exposure to jeep- or tractor-drawn boom applicator will be similar to that described by Wolfe et al. (1961) for tractor-drawn boom spraying of the herbicide DNOSBP. Wolfe found a mean dermal exposure of 22.4 mg/hour and a mean inhalation exposure of 0.12 mg/hour at an average treatment rate of 3 lbs/acre. In the above case, dermal exposure from the actual mixing/loading operation has been factored out and the 22.4 mg/hour represents the actual spraying operation.

H. Dermal exposure to downwind spray drift has been estimated by Severn et al. (1978) from data originally developed by Yates et al. (1967). This data

r loaders will receive their primary exposure to diflubenzuron

the dust. Respiratory exposure will be primarily during the

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lb bag) is 10 seconds. The amount of resi

estimated to be mg/m^3 during this operation.

Dermal exposure of mixer/loaders to Dimilin W-25 is also

with the sheet-tear bag opening operation. However,

data available (Degler, 1981) is for "tank-fill

portion of the exposure over the entire mixing/load

estimate is 52.9 mg/hour for a 2 Guthion wettable

filling requires 40 minutes per day to mix

each, when either aerial application or

Only one mixer/loader is assumed per treatment operation

agent will be utilized.

bystanders will be permitted to be directly exposed beneath the

Spray areas will be posted to assure adherence to this

treatment scouting and cultural activities in the field

result in substantial respiratory or dermal exposure.

sure to jeep- or tractor-drawn boom applicator will be similar to

Wolfe et al. (1961) for tractor-drawn boom spraying of the

Wolfe found a mean dermal exposure of 22.4 mg/hour and a mean

of 0.12 mg/hour at an average treatment rate of 3 lbs/acre.

dermal exposure from the actual mixing/loading operation has

22.4 mg/hour the actual spraying

has been estimated by Brown et

al. 1981). This data

should be applicable to aerial sprays of diflubenzuron provided a correction is made for the particle size distribution differential. While no direct estimate can be developed for drift of a 200 micron VMD spray (spray charactristics from Table 23), inspection of Table 4 from Yates et al. (1967) for 420 microns and 290 microns VMD sprays suggests that as a conservative estimate, the 200 VMD droplets would not lead to more than 2x the deposit calculated for a 420 micron VMD spray. Corrected value for the data of Severn et al. (1978) are shown in the next section under "Unit Exposure Calculations."

Respiratory exposure to such aerial drift will be negligible in comparison to the dermal and is not considered here.

I. The exposure of spray pilots to endrin during the application of 60 lb AI/100 gallons of finished spray to various vegetable crops has been measured by Jegier (1964a). Jegier found a potential inhalation exposure of 0.08 mg/hour and a potential dermal exposure of 1.18 mg/hour to pilots in an enclosed cockpit. The rate of application was 1 lb AI/acre. Assuming that exposure is directly proportional to treatment rate/unit area and that the aircraft used are similar, a correction factor

$$\frac{0.06}{1.0} = 0.06$$

is used to calculate unit exposure from maximum use rate conditions.

Unit exposure calculations. Based on the use patterns and assumptions discussed above, the following Unit Exposure Calculations can be made:

A. Mixer/Loader

1. Dermal Exposure (see assumptions B, C)

a. Aerial Applicators

52.9 mg/hour x 4/6 hour/day = 35 mg/day

B. Tractor Boom Spray Applicators

52.9 mg/hour x 6 hours/day = 317 mg/day

2. Respiratory Exposure (see assumption A)

$10\ mg/m^3 \times 1.8\ m^3$/hour (normal breathing rate for light work) x 0.0028 hours/bag opening x 0.25 (concentration factor) = 0.013 mg diflubenzuron/5 lb bag opening

B. Tractor-drawn boom applicator (see assumption G)

1. Dermal Exposure

$$22.4\ \text{mg/hour} \times 6\ \text{hours/day} \times \frac{0.125}{3} \doteq 5.6\ \text{mg/day}$$

2. Resiratory Exposure

$$0.12\ \text{mg/hour} \times 6\ \text{hours/day} \times \frac{0.125}{3} = 0.03\ \text{mg/day}$$

Note: This same person will also do mixing and loading.

C. Pilot Exposure (see assumption I and Table 23).

1. Dermal Exposure

1.18 mg/hour x 1 hour/day x 0.06 = 0.08 mg/day

2. Respiratory Exposure

0.08 mg/hour x 1 hour/day x 0.06 = 0.005 mg/day

D. Residents Living Immediately Adjacent to Spray Areas (see assumption H).

Table 25 provides an estimate of dermal exposure that might be expected of persons standing outdoors during the actual spray operation. Since the great preponderance of dermal exposure is due to large droplets (mass varies by the cube of the droplet radius) and since residents remaining indoors at the time of spraying will be protected from all but the finest droplets, dermal exposure to such individuals will be negligible.

Table 25. Potential diflubenzuron deposition on human skin downwind from target area after aerial application to cotton.

Downwind Distance (meters)	Potential Dermal Deposition from Spraying (micrograms)[a,b]
25	640
45	330
96	150
196	70
398	35

[a]Assumes 0.3 m^2 of exposed skin surface. [b]Data of Severn et al. (1978) corrected for concentration ($\frac{0.125}{0.25} = 0.5$) and particle size (2X) to give an effective correction factor of 1X.

Considering the areas for potential diflubenzuron treatment, the assumption is made that the average size cotton farm is 112 acres (total cotton acreage number of farms). For the diflubenzuron-treated acres (1,540,000 projected), this would mean 13,750 farms involved. Assuming an average family of 4 per farm and one additional family of 4 on each 100 acres, the total potential population involved would be 110,000 people. It is not likely that this number of people would be outside during spraying. The assumption is that 1 out of 4 could be outside, which makes the potential number exposed to be 27,500.

SOYBEANS

Formulation and Use Patterns. The wettable powder formulation of diflubenzuron to be used on soybeans is the same as that previously described for cotton. Application to soybeans will be at the rate of 0.0312 - 0.0625 lb AI/acre. One repeat application is permitted if damaging numbers of target insect larvae reappear. About 90% of the soybean applications will be made by fixed-wing aircraft and the remainder by tractor-drawn boom sprayer. Aerial application requires sufficient water added to the formulation to provide 1-3 gallons/acre coverage. Ground application will be made at a rate of 35 gallons finished spray/acre. Detailed parameters for fixed-wing aircraft application of diflubenzuron to soybeans are indicated in Table 26.

The three pests of soybeans that are effectively controlled by diflubenzuron are the velvetbean caterpillar, green clover worm, and the Mexican bean beetle. The soybean committee of the Diflubenzuron Assessment Group has projected the areas of infestation for each of these pests and the acres currently impacted at three infestation levels. Assuming the current worst case, the potential acreage that might be treated would be 1,250,000.

ng the areas for potential diflubenzuron treatment, the assumption

t average size cotton farm is 112 acres (total cotton acreage

for). For the diflubenzuron-treated acres (1,540,000 projected),

ld mean 13,750 involved. Assuming an average of

additional family of 4 on each 160 acres, the total potential population would be 110,000 people. It is not likely that this num

ou site during spraying. The assumption is that 1 out of could be

which makes the potential number exposed to be 27,500

ma ation and Use Patterns. The wettable powder formulation of

zuron to be used on soybeans is the same as that previously dis

ted. Application to soybeans will be at the rate of 0.0312 - 0.06

One repeat application is permitted damaging numbers of target

reappear. About 90% of the soybean applications will be made

y aircraft and the remainder by tractor-drawn boom sprayer. Applicat

requires sufficient water added to the formulation to provide

e coverage. Ground application will be made at a rate of 25 gallons

/acre. Detailed parameters for fixed-wing aircraft application of

ron to soybeans are indicated in Table 25.

three pests of soybeans that are effectively controlled

zuron are the velvetbean caterpillar, green clover worm, and the Mexican

The soybean committee of the Diflubenzuron Assessment Group has

reas of infestation for each of these pests and the acres

ge infestation levels. Assuming the current usage

hat might treated would 1,300,000.

Table 26. Parameters for fixed-wing aircraft application of diflubenzuron to soybeans.

Formulation	W25 wettable powder
Equipment	Fixed-wing aircraft
Representative nozzle	Teejet 8006, fan spray
Flying speed	120 mph
Boom pressure	20 psi
Altitude	5-10 feet
Application rate	0.0625 lb AI/acre (maximum)
Volume of application	1 gallon
Frequency of application	1.1 (average - 10% may receive 2 applications
Droplet size	200 microns VMD
Hours spent flying/day	5
Hours spent in spray swath/day	1
Average length of spray swath	1/2 mile
Average width of spray swath	40 feet
Average acres treated/day	500
Average acres treated/week/applicator	2,500
Average acres treated/season/applicator	21,000
Protective equipment (pilot)	Coveralls

The three soybean pests are regionalized with very minimal overlap between regions. Also, the velvetbean caterpillar is a late season pest (August-October), while the Mexican bean beetle apparently infests early planted soybeans first and then moves to other fields later in the season. Green clover worms, in general, infest soybeans earlier than do the other two pests but, with the exception of the midwest, do not pose an economic threat.

If one assumes that an applicator will treat an average of 500 acres per day, the in-swath potential exposure time will be 10^+ minutes per 100 acres or 60 minutes per day. Also, assuming the worst case potential exposure, the 1,250,000 infested acres will be treated with diflubenzuron. Assuming 500 acres treated per day, operating 5 days per week for a period of 4 months (June, July, August, and September) and moving from region to region for the three pests, the acres treated per applicator could reach 40,000. This would calculate to an in-swath exposure time totaling 80 hours. It is not likely that one pilot would cover this acreage as there is a tendency to be regionalized with a base of operation. However, it does reflect the worst case exposure situation. Calculating potential exposure based on infested acres within a state is believed to more nearly reflect applicator practice.

The period and frequency of exposure for the mixer/loader will be the same as for cotton for any given time period, since the same individuals (applicator and mixer/loader) will be treating soybeans and cotton where these crops are growing in the same area.

Assuming conditions outlined in Table 27 to be representative of soybean applications, the measurement of dermal and inhalation exposure of the mixer/loader can be developed.

three soybean pests are regionally

Also, the velvetbean caterpillar is a late season pest (August-

while the Mexican bean beetle apparently infests early pla

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ing conditions outlined in Table 27 to be representative of

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be developed.

Table 27. Mixer/loader information for aerial application of diflubenzuron to soybeans.

Capacity of mixing or nurse tank	500 gallons
Volume of diflubenzuron solution applied/Acre	1 gallon
Rate of diflubenzuron (AI/Acre)	0.0625 lb
Number of applications per season	1
Total exposure time for mixing and loading/day	40 minutes
Acres treated/day/applicator	500
Load capacity of plane spray tank	150
Volume of transfer pump on mixing unit	15 gal/minute

Assuming a volume per acre of 1 gallon of diflubenzuron solution and the applicator treats 500 acres per day, the 500 gallon mixing unit would meet the needs for a full day's operation. Mixing this volume of spray solution daily would eliminate the concern of leaving excess in the mix unit over-night, when the wettable powder would separate and require additional agitation time the following morning to be confident of a uniform mix.

Assumptions. The assumptions made to permit calculations of diflubenzuron exposure resulting from its application to soybeans are identical to those made under A-I for the cotton analysis.

Unit Exposure Calculations. Based on the use patterns and assumptions previously discusssed, the following unit exposure calculations can be made:

A. Mixer/Loader

1. Dermal Exposure (see assumptions B, C)

a. Aerial applicators

52.9 mg/hour x 0.5 hours/day - 26.5 mg/day

b. Tractor boom spray applicators

52.9 mg/hour x 6 hours/day = 317 mg/day

2. Respiratory Exposure (see assumption A)

$10\ mg/m^3 \times 1.8\ m^3/hour$ (normal breathing rate for light work) x 0.0028 hours/bag opening x 0.25 (concentration factor) = 0.013 mg diflubenzuron/5 lb bag opening

B. Tractor-Drawn Boom Applicators (see assumption G)

1. Dermal Exposure

$$22.4\ mg/hour \times 6\ hours/day \times \frac{0.06}{3} = 2.7\ mg/day$$

2. Respiratory Exposure

$$0.12 \text{ mg/hour} \times 6 \text{ hours/day} \times \frac{0.06}{3} = 0.015 \text{ mg/day}$$

NOTE: This same person will also do mixing and loading.

C. Pilot Exposure (see assumption I and Table 26)

1. Dermal Exposure

1.18 mg/hour x 1 hour/day x 0.06 = 0.07 mg/day

2. Respiratory Exposure

0.08 mg/hour x 1 hour/day x 0.06 = 0.005 mg/day

D. Residents Living Immediatlely Adjacent to Spray Areas (see assumption H).

Table 28 provides an estimate of dermal exposure that might be expected of persons standing outdoors during the actual spray operation. As with potential exposure from the cotton applications, persons indoors will not receive significant exposure from diflubenzuron application to soybeans.

Considering the areas for potential diflubenzuron treatment on soybeans, the assumption is made that the average size soybean farm is 102 acres (soybean acreage ÷ number of farms). For the diflubenzuron treated acres (1,250,000 projected), this would mean 12,255 farms involved. Assuming an average family of 4 persons per farm and one additional family on each 100 acres, the total population involved would be about 100,000. It is not likely that this number of people would be outside during spraying. The assumption is that 1 out of 4 could be outside which makes the potential number exposed to be about 25,000.

MOSQUITOES

<u>Formulations and Use Patterns</u>. The wettable powder formulation of diflubenzuron to be used in mosquito control is the same as that previously

Table 28. Potential diflubenzuron deposition downward from target area after aerial application to soybeans.

Downwind Distance (meters)	Potential Dermal Deposition from Spraying (micrograms)[a,b]
25	320
45	165
96	75
196	35
398	18

[a]Assume 0.3 m^2 of exposed skin surface. [b]Data of Severn et al. (1978) corrected for concentration $\frac{0.06}{0.25} = 0.25$ and for particle size

(2x) to give an effective correction factor of 0.5x.

described. When mosquito abatement district equipment requires granules for aerial application, a 0.25% active ingredient granule may be made by mixing 30 lbs Dimilin W-25, 2957 pounds of coarse sand (20/30 mesh), 10 pounds of larvicide oil, and 3 pounds of Hysil followed by mixing for 30 minutes.

Diflubenzuron will be applied to intermittent fresh waters for mosquito control at a rate of 0.025 - 0.04 lb AI/acre of water. For aerial application, the granular formulation described above is used at a rate of 10-16 pounds of finished formulation/acre. About 75% of the total acrage to be treated will require the granular formulation. The remaining 25% of the total acreage will be treated about equally with tractor- or jeep-mounted boom sprayers at 25 gallons/acre, and with knapsack back sprayers at 25-100 gallons/acre. The proposed mosquito label permits the use of 5-100 gallons of finished spray/acre, depending on the equipment used. The parameters indicated in Tables 29-31 are considered representative for the proposed mosquito uses.

The extent of exposure to workers preparing the granular material will depend on the quantity needed per day and the kind of mixing equipment available. Assuming the applicator will cover the same acreage with granular as with liquid spray equipment, the quantity of granules needed for a day's operation would be a maximum of 9,000 pounds (500 acres x 16 lbs/acre). Under these conditions and assuming equipment that would mix 3,000 pounds per batch, 3 mixings per day would be required. The proposed label text indicates the time required for the preparation of 3,000 pounds to be 65 minutes. Thus, the exposure time to the formulators in preparation would be 3 1/4 hours per day, which includes loading the ingredients, mixing and unloading. The average number of workers involved in formulating is estimated at 3.

Assuming the load capacity of the plane to be 1,200 pounds, which would equal that for liquid (150 gallons x 8 lbs/gallon), the loader would be

Table 29. Parameters for fixed-wing aircraft application of diflubenzuron (wettable powder formulation) in mosquito control.

Formulation	W25 wettable powder
Equipment	Fixed-wing aircraft
Representative nozzle	Teejet 8006, fan spray
Flying speed	120 mph
Boom pressure	20 psi
Atlitude	variable - depending on site
Application rate	0.025-0.04 lbs AI/acre
Volume of application/acre	1 gallon
Frequency of application	7-10 days
Number of applications/season	3
Hours spent flying/day	5
Hours spent in spray swath/day	1
Average length of spray swath	variable
Average acres treated/day	500
Protective clothing (pilot)	Coveralls

Table 30. Parameters for fixed-wing aircraft or helicopter application of diflubenzuron (granular formulation) in mosquito control.

Formulation	Granular - 0.25 percent AI
Equipment	Fixed-wing aircraft or helicopter
Application rate	10-16 lbs/acre of granules
Frequency of application	7-9 days
Number of applications/season	3
Hours spent flying/day	5
Hours spent in spray swath/day	1
Number of workers involved in treatment	2 - applicator and loader
Number of workers involved in formulating	3

Table 31. Projected extent of use of diflubenzuron in mosquito control, and potential extent of human exposure during the application process.

Number of acres to be treated	400,000
1. Aerial - fixed wing aircraft (granular)	300,000
2. Ground application (liquid and granular)	100,000
a. Low volume - tractor, jeep, or truck mounted sprayers	50,000
(1) Applied as liquid	25,000
(2) Applied as granular	25,000
b. Hand-gun, knapsack, or granular applicator	50,000
(1) As a liquid spray	25,000
(2) As granular	25,000
Total number of workers involved in hand application	500
Total number of workers involved in low-volume treatments - tractor, jeep or truck	100
Total number of pilots involved in aerial treatment	35
Total number of mixer/loaders involved	100
Number of by-standers present in ground application areas per 5 acres	4
Total number of people exposed in ground application (Application is with hand guns or granular applicators on limited size areas - 1-10 acres)	None
Total number of people present in aerial granular application areas per 100 acres	4
Total number of people exposed in aerial granular application. (The granular formulation is on sand, with oil as a sticker for the diflubenzuron. There is virtually no dust once formulated, the sand particles fall rapidly, and thus no exposure)	None
Time of application for mosquito control	April-October
Percentage of total acreage treated by months	April 5%; May 5%; June 10%; July 30%; August 30%; September 10%; October 10%.

refilling the plant hopper 8 times per day. The worst case exposure to the loader would be if the granular were packaged in 50 pound bags, which would require the handling of 24 bags for each loading. Assuming hand loading under these conditions, the loading time would approximate 30 minutes per load. If the granular were handled in bulk and an auger loader was used, the exposure time per load should not exceed 15 minutes.

Assumptions. Certain of the assumptions made to permit calculations of diflubenzuron exposure resulting from its application to water for mosquito control are the same as those previously discussed and used in the cotton and soybean exposure calculations. The assumptions are as follows:

A. That a large cement mixer is used to mix the diflubenzuron-sand-oil formulation.

B. That a dust level of 10 mg/m^3 will be in the general vicinity of the mixing apparatus during the first 2 minutes of the 65-minute filling and mixing operation, and that a dust cover is placed over the mixer during the entire mixing process.

C. That once formulated, the granular formulation is no longer "dusty" due to the larvicide oil acting as a dust preventative.

D. Same as Assumption G, cotton exposure section. Assume 4 hours actual spraying time/day.

E. Caplan et al. (1956), working with aerially applied malathion in oil sprays, applied 0.46 lb/0.76 gallons (calculated from data)/acre and determined a dermal exposure directly beneath the spray for exposed body areas of 3.556 mg. Assuming a direct relationship between treatment rate/unit area and disregarding differences in spray density and particle size distribution, a correction factor for dermal exposure can be made:

plant hopper 8 times per day. To what extent exposure is
mold be if the granular were packaged in 50 pound bags, which would
handling of 24 bags for each loading. Assuming that
conditions, the loading time would be ... 30 minutes per
anular were handled in bulk and an auger load ... ss
load should not exceed 15 minute

ssumptions. Certain of the assumptions made in
enzuron exposure resulting from ... application in water for dust
are the same as those previously discussed ... in the cotton
exposure calculations. The assumptions are as follows:

at a large cement mixer is used to mix the diflubenzuron-treated oil

That a dust level of 10 mg/m^3 will be in the general vicinity of t
paratus during the first 2 minutes of the 45-minute filling
and that a dust cover is placed over the mixer during the
on

That once formulated, the granular formulation is no
arvicide oil acting as a dust preventative.
ame as Assumption 5, cotton exposure section. Assume 4 hours actual

al. (1966), working with actually applied malathion in oil
15 lb/0.76 gallons (calculated from data)/acre and determined
beneath the spray for exposed body areas of 3.346 mg
... treatment rate/unit area and distr...
particle size distribution, a correction factor

$$\frac{0.04}{0.46} = 0.087$$

Respiratory exposure under the same conditions is negligible (<1/500th of dermal).

F. Same as assumption I, cotton exposure section, except that the correction factor is calculated as follows:

$$\frac{0.04}{1.0} = 0.04$$

G. Based on data by Wolfe and Durham (1974) relative to backpack sprayer-handgun application of fenthion for mosquito control, it can be calculated that applicators receive a dermal exposure of 0.177 pints spray/applicator/8 hour work day.

H. Same as assumption A, cotton exposure section.

I. Same as assumption B, cotton exposure section.

J. Tank filling for aerial application requires 30 minutes/day to mix and transfer 1 batch of 500 gallons. A similar time is required to mix 1 batch of 200 gallons/day for tractor boom sprayers. One mixer is involved/operation.

Unit Exposure Calculations

A. Mixer/loader (see assumption H, I, J)

1. Aircraft and Tractor-drawn operations

a. Dermal exposure

52.9 mg/hour of tank fill x 0.5 hour tank fill/day = 26.5 mg/day

b. Respiratory Exposure

10 mg/m^3 x 1.8 m^3/hour (normal breathing rate for light

work) x 0.25 (concentration factor) x 0.0028 hours/bag opening = 0.013 mg diflubenzuron/5 lb bag opening

B. Pilots (see assumption F)

1. Dermal exposure

1.18 mg/hour x 1 hour/day x 0.04 (correction factor) = 0.05 mg/day

2. Respiratory exposure

0.08 mg/hour x 1 hour/day x 0.04 (correction factor) = 0.003 mg/day

C. Residents Living in Sprayed Areas Standing Outdoors During Actual Spraying (see assumption E)

3.556 mg/0.3 m^2 exposed body area x 0.087 = 0.31 mg/0.3 m^2 exposed body area

D. Formulator (Granules) (see assumptions A, B, C, I)

1. Dermal exposure

52.9 mg/hour x 3.25 hours/days = 172 mg/day

2. Respiratory exposure

10 mg/m^3 x 1.8 m^3/hour (normal breathing rate for light work) x 0.25 (concentration factor) x 0.033 hours exposure/3,000 lb batch x 4 batches/day = 0.594 mg/day

E. Backpack sprayer (see assumption G)

1. Dermal exposure

0.022 gallon formulation (0.177 pint)/day x 0.0016 lb AI/gallon x 454,000 mg/lb = 15.98 mg/day

NOTE: Assumes 25 gallons finished spray and 0.04 lb AI diflubenzuron/acre

F. Tractor-drawn Boom Applicator

1. Dermal exposure

$22.4 \text{ mg/hour} \times 4 \text{ hours/day} \times \frac{0.04}{3}$ (application rate factor) = 1.19 mg/day

2. Respiratory exposure

$0.12 \text{ mg/hour} \times 4 \text{ hours/day} \times \frac{0.04}{3}$ (application rate factor) = 0.0064 mg/day

GYPSY MOTH

Formulation and Use Patterns. The 25% wettable powder formulation will be used in the application of diflubenzuron to hardwood trees for control of the gypsy moth. It will be applied at a rate of 0.0625 - 0.125 lb AI/acre in a total spray volume (water) of 0.5-2.0 gallons/acre. For mist blower applications, the rate is 1.5-10.0 gallons/acre. Application is to be made only by federal or state personnel involved in pest management programs, or persons under their direct supervision. Application is restricted to a single treatment prior to full leaf expansion when the larvae are in the first, second, and third instars. Application by aircraft will involve the fixed-wing type. Representative parameters for the use of diflubenzuron in gypsy moth control are shown in Table 32.

Based on actual township demographic studies in Michigan for the areas being sprayed for gypsy moth, the area averaged 1 home/10 acres. Assuming an average of 4 people/home, this would represent 4 people/10 acres. Considering time of treatment (May 15 - June 10), it is not likely that more than one person/home would be outside during spraying.

For the Northeast (PA, NJ, DE, NY), the area might average 2 homes/10 acres. Thus, 8 people/10 acres would be subject to potential exposure.

Table 32. Parameters for fixed-wing aircraft application of diflubenzuron for control of the gypsy moth.

Formulation	W25 wettable powder
Equipment	Fixed-wing aircraft
Nozzle size	8002-8006, Tee-jet
Droplet size	90% over 200 microns
Flying speed	100 mph
Boom pressure	20-40 psi
Flying height	10-30 feet
Rate of application	0.0625 lb AI/acre/season
Volume of application	1 gallon
Carrier	water
Number of applications	1 per season
Application time	May 1 to June 10
Note: Approximately 50% foliage development which will vary the timing of application because of elevation and geographic location.	
Swath width	60 feet
Swath length	1/2 mile
Flying time/day (avg)	3 hours
Swath time/day (avg)	1 hour
Days flying/week	5
Number of hours in swath/season for 6 week spray period)	30 hours (5 hours/week for 6 weeks)
Frequency of treatment	Possibly one treatment every 3-5 years

Assuming that 1 person out of 4 per family would be outdoors at the time of spraying, the direct exposure would be 2 people/10 acres treated.

In other areas of the Northeast, the areas to be treated will be totally residential and there will be as many as 300 or more people/10 acres. This is assuming 1/8 acre lots with 4 people/family, or more than 30 people/acre. Again, assumming 1 person of 4 to be outdoors at the time of treatment, this would be 8 people/acre exposed for a period not to exceed 5 minutes. For the more Western areas of gypsy moth infestation, the concentration of human inhabitants would likely reflect the Midwest condition. The total projected acreage for gypsy moth treatment is about 500,000. This is the estimate of need for control, containment, and eradication programs for 1979, 80, and 81.

Assumptions. The following assumptions were made to permit calculations of human exposure as a result of diflubenzron's use against the gypsy moth:

A. Same as assumption A, cotton exposure section

B. Same as assumption B, cotton exposure section

C. Tank filling operations require 40 minutes/day for one 500 gallon mix/day. At 0.0625 lb AI of diflubenzuron/gallon and 1 gallon finished spray/acre, 500 acres would be treated, requiring 25 bag openings (5 lb. bags).

D. Same as assumption E, mosquito exposure section, except that the correction factor is calculated as follows:

$$\frac{0.06}{0.46} = 0.13$$

E. Same as assumption I, cotton exposure section.

Unit Exposure Calculations. Based on the assumptions and use patterns discussed above, the following unit exposure calculations can be made.

A. Mixer-Loader

1. Dermal exposure (see assumptions B, C)

52.9 mg/hour x 4/6 hours/tank filling = 35.5 mg/day

2. Respiratory exposure (see assumption A)

10 mg/m^3 x 1.8 m^3/hour (normal breathing rate for light work) x 0.0028 hours/bag opening x 0.25 (concentration factor) = 0.013 mg/bag opening

B. Pilots (see assumption E)

1. Dermal exposure

1.18 mg/hour x 1 hour/day x 0.06 = 0.07 mg/day in spray swath

2. Respiratory exposure

0.08 mg/hour x 1 hour/day x 0.06 = 0.005 mg/day in spray swath

C. Residents Living Within Sprayed Area (see assumption D).

3.556 mg/0.3 m^2 of exposed body surface x 0.13 = 0.46 mg/0.3 m^2 of exposed body surface.

DOUGLAS-FIR TUSSOCK MOTH

Formulation and Use Patterns. The 25% wettable powder formulation will be used in the applications of diflubenzuron to coniferous trees for control of the Douglas-fir tussock moth. It will be applied a maximum of once/year at a rate of 0.125 lb AI/acre. Because of the rugged terrain involved, all treatments will be conducted by helicopter. Table 33 gives representative parameters for diflubenzuron's use against the tussock moth.

Table 33. Parameters for aerial (helicopter) application of diflubenzuron for control of the Douglas-fir tussock moth.

Formulation	W25 wettable powder
Particle size of formulation	2-5 microns
Equipment	Helicopter
Representative nozzle	Beco-Mist - with #80 head
Particle size distribution of nozzle	90% greater than 200 microns with less than 10% less than 100 microns
Flying speed	80 mph
Boom pressure	30-40 psi
Altitude	25-50 feet above foliage
Application rate	0.125 lbs AI/acre
Volume of application	1 gallon/acre
Frequency of application	1 treatment/season
Time of application	Early morning - 5-9 a.m.
Hours spent flying/day	3-4 hours
Note: Because of weather conditions, the average flying time will be 3-4 hours out of 10 days and 10 days per pilot out of 30 day season.	
Hours spent in spray swath/day	3
Average length of spray swath	Highly variable
Average width of spray swath	125 feet
Average acres treated/day	20 acres/minute 1,200 acres/hour 3,600 acres/day 36,000 acres/season
Number of flaggers involved	None
Average size of nurse tank	1,000 gallons
Note: Depends on conditions, including: Does he haul his own water to loading site Number of planes operating Size of the job Specifications of the contract	
Average load of helicopter	100-125 gallons

Table 33 Continued

Capacity of nurse tank transfer pump for loading	50 gallons/minute
Time required to fill plane	2-2½ minutes
People involved with loading and mixing	1-2

Note: Will depend on the number of planes operating from nurse truck. If operating from a heli-port, will likely be two.

Type of packaging of active ingredient	Mostly 25 lb. fiber drums with plastic liners
Total acres to be treated per season	50,000
Predicted occurrence of outbreaks	Once every 9 years
Total people exposed per 100 acres	1
Total people exposed per season	500

The forest areas in the Western states where tussock moth outbreaks have occurred are principally non-populated areas. Thus, the assumption is made that a maximum of 1 person/100 acres would be representative of potential bystander exposure. The agreage projected for annual treatment is 50,000. Outbreaks are projected to occur about once every 9 years and the next projected outbreak is 1983. Assuming the above density of population, the maximum number of people exposed would be 500.

Assumptions. The following assumptions were made in the assessment of human exposure to diflubenzuron as a result of its potential use against the Douglas-fir tussock moth:

A. Same as assumption A, cotton exposure section.

B. Same as assumption B, cotton exposure section. Since exposure is related to pouring time - the 25 lb. drum would result in equivalent exposure to the five - 5 lb. bags.

C. Tank-filling operations require 30 minutes/day to mix and transfer 1 batch of 500 gallons.

D. Pilot exposure to diflubenzuron sprayed from helicopters will be negligible in comparison to fixed-wing aircraft due to the aerodynamic position relationships of the helicopter rotor, the pilot, and the spray boom. It can be expected that most turbulence coaxial to the helicopter spray path will be at the trailing edge and removed from the pilot.

E. Same as assumption E, mosquito exposure section, except that the correction factor is calculated as follows:

$$\frac{0.125}{0.46} = 0.27$$

In the Western states where tussock moth outbreaks ha[illegible]

[illegible] non-populated areas. Thus, the assumption [illegible] made

[illegible] 1 person/100 acres would be representative of potential bystander

[illegible] the acreage [illegible] for annual treatment is 50,000. Outbreaks are

[illegible]d to occur about once every [illegible] years and the next projected outbreak

[illegible]ing the above density of population, the maximum number of people

[illegible] would [illegible].

Assumptions. The following assumptions were made in the assessment [illegible]

exposure to diflubenzuron as a result of its potential use against the

[illegible]-fir tussock moth:

Same as assumption A, cotton exposure section.

Same as assumption B, cotton exposure section. Since exposure is

related to mounting time - the 25 lb. drum would result in equivalent

exposure to the five [illegible] lb. bags.

Tank-filling operations require [illegible] minutes/day to mix and transfer [illegible]

batch of 500 gallons.

Pilot exposure to diflubenzuron sprayed from helicopters will be

negligible in comparison to fixed-wing aircraft due to the aerodynamic

position relationships of the helicopter rotor, the pilot, and the spray

boom. It can be expected that most turbulence coaxial to the helicopter

spray path will be at the trailing edge and removed from the pilot.

[illegible] as assumption E, mosquito exposure section, except that the

[illegible] factor is calculated as follows:

$= 0.27$

<u>Unit Exposure Calculations</u>. Based on the assumptions and use patterns discussed above, the following unit exposure calculations can be made.

A. Mixer/Loader

1. Dermal exposure (see assumptions B, C)

   52.9 mg/hour x 0.5 hours/tank filling x 1 tank/day = 26.5 mg/day

2. Respiratory exposure (see assumption A)

   10 mg/m^3 x 1.8 m^3/hour (normal breathing rate for light work) x 0.0028 hours/bag opening x 0.25 (concentration factor) = 0.013 mg/bag opening

B. Pilots (see assumption D)

   No significant dermal or respiratory exposure

C. Residents Living within Sprayed Areas (see assumption E)

   3.556 mg/0.3 m^2 body surface x 0.27 = 0.96 mg/0.3 m^2 exposed body surface.

Table 34 gives a summary of the exposure projections discussed above for diflubenzuron's use on cotton, soybeans, forests, and against mosquito larvae.

Table 34. Summary of estimated maximum exposure to diflubenzuron of applicators and associated personnel, and bystanders, during the application of diflubenzuron for insect control on cotton, soybeans, and forests, and its direct application to water for mosquito control.

	Maximum estimated exposure from indicated application[a]									
	Cotton		Soybeans		Forests-GM[b]		Forests-TM[b]		Mosquito	
Person exposed	D[c]	R[c]	D	R	D	R	D	R	D	R
Mixer/Loader	1.9	0.013	1.9	0.013	0.16	0.013	0.16	0.013	0.16	0.013
Tractor drawn boom applicator	5.6	0.03	2.7	0.015	--	--	--	--	0.30	0.0016
Pilot	0.08	0.005	0.07	0.005	0.07	0.005	--	--	0.05	0.003
Backpack sprayer	--	--	--	--	--	--	--	--	15.98	--
Formulator[h]	--	--	--	--	--	--	--	--	1.03	0.594
Bystander[i]	0.640	--	0.320	--	0.46	--	0.96	--	0.31	--

[a]Figures in mg/unit time or event as indicated in appropriate footnotes. [b]GM = gypsy moth; TM = Douglas-fir tussock moth. [c]D = dermal exposure; R = respiratory exposure. [d]mg/day. [e]mg/5 lb bag opening. [f]mg/0.3 m^2 of exposed skin/application. [g]All spraying done by helicopter, with no significant projected pilot exposure due to aerodynamic properties (see assumption D, mosquito exposure section). [h]Formulator of granules for mosquito applications. [i]Residents or other persons outside in areas immediately adjacent to treated areas or, in the case of forest applications, directly beneath the spray.

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